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ART. XVIII.—*Second Report on Observations of the Aurora Borealis*, 1850–1851; by J. H. LEFROY, Capt. R. A., being a Circular Letter to officers of Honorable Hudsons' Bay Company, dated Magnetical Observatory, Toronto, April 13, 1852.

I AM obliged to adopt the same method as before of communicating with the gentlemen from whom I have requested observations on the Aurora, namely, by a circular, to save the needless repetition in private letters of the information which it is incumbent upon me to give, of the result of those of the first winter.

Registers of aurora have reached me from the following quarters:

a Peel's River,	October 1850, to April 1851,	Mr. A. Peers.
a Youcon,	January to May 1851,	Mr. Hardisty.
a Fort Good Hope,	November 1850,	Mr. McBeath.
a Fort Confidence,	October 1850, to April 1851,	Dr. Rae.
a Fort Simpson,	October 1849, to May 1850,	Dr. Rae.
"	September 1850,	Mr. Bernard Ross.
a Pelly and Lewis,	December 1850, to April 1851,	Messrs. R. Campbell and Stewart.
a Fort Chipewyan,	November 1850, to April 1851,	Mr. J. Anderson.
b Moose Factory,	June 1850, to March 1851,	Mr. Clouston.
b Martin's Falls,	September 1850, to March 1851,	Mr. Wilson.
b Nipegon,	1842, to April 1850,	Mr. J. Anderson.
b Matawagomingen,	July 1850, to March 1851,	Mr. Colin Campbell.
b Michipicoton,	November 1849, to July 1851,	Mr. Swanston.

To each and all of these gentlemen, as well as to those who may have kept journals which have not yet reached me, I beg to tender my warmest thanks. Nothing can exceed the care and attention displayed by many of the registers, and their interest has fully equalled my expectations. Without meaning to draw invidious comparisons, I cannot deny myself the pleasure of espe-

cially naming here those of Mr. Swanston, Mr. Clouston, and Mr. Anderson; the first of these is a model of completeness and conciseness, Mr. Swanston having generally recorded the state of the sky and the weather every hour from dark to 10 P. M., and in terms which are always definite and expressive.

The registers have been continued at the Military Guardrooms of the Royal Artillery in Canada, and at a great number of stations of observation in the United States. I have now in my hands, through the kindness of Professor Henry, Secretary to the Smithsonian Institution, returns from upwards of an hundred observers, for 1849, 1850, and part of 1851, at stations scattered through all the States, from the Atlantic to the Mississippi. Not having received observations from any of the stations on the Saskatchawan, or Lake Winnipeg, there is a pretty wide blank, extending from Lake Athabasca to Lake Superior, in the chain by which it was hoped to trace and identify, displays from the polar circle downward to Canada, but I trust in future years some at least of the intermediate posts will oblige me with a journal: and if each observer will bear in mind that others, hundreds, and some of them thousands of miles off, are noting down the features of the very displays he may be looking at, as it appears to them, and that from a comparison of all these accounts, it is hoped to arrive at definite views concerning this most singular phenomenon, he cannot fail to see the value which every clear, distinct, and definite record of facts and particulars will possess, and to acquire a greater interest in the subject than the constant repetition of familiar descriptions might otherwise afford.

It has been often stated vaguely that aurora appears every clear night. This is certainly not true of any one station, as far as the earlier hours are concerned, we are still short of proof that it is true in the widest meaning; indeed, the statement, if true, would carry little weight with it, without the addition of dates, facts, and particulars. These, however, our registers promise, for the first time, to supply. Observations begin to be general in October, 1850. In that month we have evidence of it every night except four, 20, 21, 22, 23, one of them clouded everywhere, one of them full moon, the rest partially clouded. In November, 1850, every night but two, 22 and 23, the former, however, of these was generally clear and no moon. In December, 1850, every night but five, 5, 10, 18, 19, 20, but all the displays of a feeble character. In January, 1851, every night but two, 5, 12, many of the displays very feeble, several of them seen only by Mr. Anderson at Athabasca, and on the whole, a much smaller proportion than usual, extending to low latitudes. In February we have it every night,* some of the displays of great beauty, although I imagine they will have been far exceeded by those of February, 1852. The display of February 18th, 1851, was one of

* Every night but two, February 2 and 16.

those remarkable instances of the simultaneous *absence of cloud*, and intense development of aurora over a very large part of the whole northern hemisphere, which, from their frequent occurrence appear to have more than an accidental connection. It was seen at every station, with exception only of the Pelly Banks, from the polar circle to the United States, where no less than thirty-eight stations have forwarded accounts of it to the Smithsonian Institution; it extended also to Europe, having been recorded at Sandwick Manse, Orkney. The display of February 28th, was almost as universal. It is remarkable that in many cases the phenomenon was first seen, in absolute time, at the most eastern stations, notwithstanding the earlier commencement of darkness at the extreme north, where the difference of latitude in some cases more than compensates the difference of longitude; it would appear from this that the aurora does not commonly appear at a station upon any meridian until that meridian generally is in darkness; a result which if established, by the whole body of evidence, will be both new and interesting. For example, in the following list I have entered the hour of sunset in meantime of Göttingen at each station, and the hour at which the aurora is first recorded in the same; it is not to be supposed that each observer seized the exact time of first visibility, but in two of the examples at least the general result is sufficiently clear; namely, that it was seen at the lower and eastern stations sooner than at the northern but more westerly stations, although there is no reason to be given why it should not have appeared at the latter, as soon as at the former, daylight having ended there:—

Table I.

	January 27, 1851, ⊙ Decl. $-18\frac{1}{2}°$, Eq. -13^m.					Feb. 18, 1851. ⊙ Decl. $-11\frac{1}{2}$. Eq. -14^m.		Feb. 28, 1851. ⊙ Decl. -8. Eq. -13^m.	
	N. Lat.		W. Long. from Gr'wich.	Sunset. Gott'g'n.	Aurora first seen.	Sunset. Gottingen.	Aurora first seen.	Sunset. Gottingen.	Aurora first seen.
Toronto,	43°	39′	−5·17	10·56	19·00	11·26	14·00	11·39	16·00
Halifax,	44	39	−4·14	10·01	....	10·18	11·49	10·15	....
Quebec,	46	49	−4·45	10·14	14·25	10·35	12·24	11·04	15·35
Newfoundland,	47	33	−3·31	8·58	....	9·32	20·11	9·48	12·40
Michipicoton,	47	56	−5·40	11·06	....	11·50	16·40	11·57	13·55
Moose Factory,	51	10	5·24	10·39	14·54	11·17	12·44	11·37	12·49
Martin's Falls,	51	52	5.47	10·58	14·30	11·36	13·01	12·00	13·01
Athabasca,	58	43	7·25	12·03	14·30	13·16	15·55	13·24	15·25
Lewis and Pelly,	61	30	8·40	13·08	21·30	14·16	....	13·41	15·58
Fort Simpson,	61	51	8·06	12·21	....	13·15	....	....	....
Youcon,	66	00	9·48	13·21	20·00	14·56	18·58	15·27	18·03
Fort Confidence,	66	54	7·55	11·21	17·00	12·55	16·25	....	....
Peel's River,	67	27	8·58	12·19	16·38	13·50	17·38	14·31	at dark

I do not offer these instances as conclusive, but they are somewhat remarkable, and I may state that having marked the Göttingen hour of the first appearance against every observation, the great majority give direct support to the inference I have drawn, and there are few or no instances contradicting it. The question

will soon be decided if the time of commencement of each display is recorded, and a note also made of the latest hour at which it may have been noticed that there was no aurora. For example, the observer takes a look out at 7, P. M., no aurora, again at 8, aurora, which is duly entered. In this connection the fact that there was no aurora at 7, is almost as important as the fact that the phenomenon was visible at 8, and should be duly entered. On 29th September, 1851, at 6·30, P. M., there was no trace of aurora at Toronto; at 6·36, a brilliant heavy serpentine band occupied the northern sky. In this instance, and in various others, the time of appearance is fixed to five or six minutes, and if at any northern station it happens to have been fixed with any thing like the same exactness, the question will be answered.

In March, 1851, we have evidence of aurora every night save three, 13, 17 (full moon,) 19; these, however, were pretty generally clear nights. Registers for April, 1851, have reached me from a few stations only, but as far as they go, give evidence of aurora every night save four, 4, 14, 15 (full moon but clouded everywhere,) and 21. The 16th of December is the only instance in the winter, of aurora seen in Canada, which escaped notice at every northern station; the number seen at northern stations which do not descend to Canada is of course considerable, as will appear from Table III.

TABLE II—*Shewing the number of nights the Aurora is recorded at each station, in* 1850 *and* 1851, *and the total number of nights in each month in which there is evidence at present, to show that the phenomenon was developed somewhere or other on the American continent. The returns will, no doubt, be extended, and some observations at present omitted as doubtful, be confirmed, and included in the totals at certain stations.*

1850.	Jan.	Feb.	March.	April.	May.	June.	July.	August	Sept.	Oct.	Nov.	Dec.	Total.
a Peel's River,	...	...	...	...	...	...	...	...	...	6	11	9	
a Fort Good Hope,	...	...	...	...	...	...	...	...	...	...	20		
a Fort Confidence,	...	...	...	...	...	...	...	...	...	12	9	15	
a Fort Simpson,	3	5	5	0	*	*	*	*	8*c*				
a Lewis and Pelly,	...	...	...	...	...	...	...	...	...	...	...	4	
a Lake Athabasca,	...	...	...	...	...	...	...	...	...	...	12	19	
b Martin's Falls,	...	...	...	...	...	...	...	...	2*f*	10	10	11	
b Moose Factory,	...	...	...	...	...	7*a*	18	19	12	15	11	13	
b Matawagomingen,	...	...	...	...	...	...	3	7	4	4	2	0	
b Lake Nipegon,	...	5	6	7†									
b Michipicoton,	3	4	3	7	1	6	5	2	1*g*	3	2	2	39
c Newfoundland,	1	6	6	1	3	3	8	6	6	9	0	3	52
c Quebec,	0	2	3	3	1	3*b*	6*c*	6*c*	7*c*	5*c*	5	3	44
c Montreal,	1	3	5	5	3								
c Halifax,	1	4	6	4	3	6	13	10	9	11	8	4	79
c Fredericton,	...	...	...	...	...	...	4	4	5	5	9		
c Kingston,	0	4	1	3	0	0	6	3	5	5	1	0	28
c Toronto,	3	3	3	6	5	3	5	4	5	9	3	1	50
c London, C. W.	1	3	3	5	3	0	3	2	5	5	0	0	30
c Somerville, N. Y.	0	7	9	8	6	8	9	14	12	7	3	4	87
Total,	11	23	23	19	15	21	27	25	21	25	27	26	261

a From the 16th to 30th June. *b* Observed by Sergeant Maiden, at Grose Isle, near Quebec—none observed at Quebec. *c* Including observations at Grose Isle. *d* Begins on the 30th. *e* From 1st to 18th. *f* Begins on the 30th. *g* Begins on the 21st.
* Twilight too strong. † Register ends.

TABLE II.—(*Continued.*)

1851.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug'st.	Sept.	Oct.	Nov.	Dec.	Year.
Peel's River,	10	16	12	1	*								
Fort Confidence,	11	15	12	4*b*									
Youcon,	7*a*	6	6	5	*								
Lewis and Pelly,	8	12	10	2*c*									
Athabasca,	20	19	20	19									
Martin's Falls,	10	12	14										
Moose Factory,	14	15	17										
Matawagomingen,	0	3	3										
Michipicoton,	2	6	7	9	5	2	5						
Newfoundland,	4	6	6	5	7	1	1	3	5	6	2	5	51
Quebec,	3	3	3	3	1	1	3	0	5	5	0	1	28
Montreal,													
Halifax,	4	5	8	9									
Fredericton,													
Kingston,	0	1	5	0	1	0	2	2	6	2			
Toronto,	2	3	7	2	3	4	5	7	9	7	5	9	63
London, C. W.,	1	2	3	0	0	2	1	2	4	1	0	2	18
Somerville, N. Y.,	0	3	5	6	6	2	6	3	9	7	1	5	53
Total,	26	26	28	26	25	9	15	11	19	13	6	13	207

In these enumerations doubtful entries are not included unless supported by an observation elsewhere in the same region. I have added the number of observations made by a most indefatigable observer (Dr. Franklin B. Hough), at Somerville, near Ogdensburgh, on the St. Lawrence, both as properly belonging to the Canadian chain of stations, and to shew that even in low latitudes a single observer, by great attention, may make surprising advance on the number of instances of aurora, which attract the attention of those who are less zealous or less favorably situated. The stations may be arranged in three groups. The first comprising all those marked (*a*) p. 1, which are from 500 to 1000 geographical miles distant from the magnetic pole; the second, those marked (*b*), which are from 1200 to 1500 miles distant; and the third, those marked (*c*), including the great majority of stations in the United States, which are from 1600 to 2000 miles distant, from the same point. Lake Athabasca, contrary perhaps to first impressions, is the nearest permanent station to this assumed centre of influence. Fort Confidence, which is not a permanent station, is of course nearer—but Fort Simpson and the other posts on McKenzie's River, notwithstanding their northerly position, are somewhat more distant.

(*a*) Commencing on the 19th. (*b*) Down to the 11th. (*c*) Down to the 10th.

TABLE III.—*Observations arranged according to position of Station with reference to the Magnetic Pole. The figures under the heading Proportion, shew the per-centage of observation of Aurora, to nights on which observation appear to have been possible, as regards the state of the sky.*

Date.	(*a*) In first circle, from 500 to 1000 miles distant.					(*b*) In second circle, from 1200 to 1500 miles distant.					
	No. of Stations.	No. of observations of Aurora.	Doubtful appearance.	Tot'ly clouded nights.	Observat'n probably possible.	Proportion per cent.	No. of Stations.	No. of observations of Aurora	Doubtful appearance.	Tot'ly clouded nights.	Observat'n probably possible.	Proportion per cent.
1850.												
January,	1	3	....	12	16	16	1	2	1	19	11	17
February,	1	6	....	10	12	33	2	5	....	20	3	62
March,	1	5	....	10	16	24	2	7	....	15	8	47
April,	1	0	....	13	17	....	2	10	....	14	6	62
May,	1	0		2	17*a*	....	1	1	1	14	16	
June,	1	6	1	4	3	....	2*b*	10	3	13	7	59
July,	....	....	....	...	....		3	19*c*	1	9	3	94
August,	....	....	....	...	....		3	22*d*	1	7	3	92
September,	1	8*f*	....	9	....	100	3	17*d*	1	7	6	74
October,	2	16	....	11	4	79	4	19	....	6	5	79
November,	4	25	....	3	3	93	4	16	1	9	5	79
December,	4	25	....	3	3	88	4	16	1	10	5	76.
1851.			....									
January,	5	28	....	2	1	96	4	15	...	11	5	79
February,	5	25	....	1	2	93	4	17	....	9	2	89
March,	5	25	....	1	4	83	4	21	....	4	6	78
April,	4*e*	23	....	2	5	82	1	9	....	16	5	64
May,	....	....	....	...	....	....	1	5	....	13	13	28
June,	....	....	....	...	....	....	1	2	....	10	18	10
July,	....	....	....	...	....	....	1	5	....	13	13	28

(*a*) Down to the 19th May. There is no night, properly speaking, at Fort Simpson in May, that is to say, twilight lasts from sunset to sunrise. (*b*) Register at Moose Factory begins on 17th June. (*c*) Including Mr. Anderson's observations *en route*. (*d*) No observations made at Michipicoton from 21st August to 20th September, but probably no conspicuous aurora occurred. (*e*) 4 stations up to the 10th, from 14th to the end, only 2. (*f*) Register from 2d to 18th September.

In the third circle (*c*) or stations from 1600 to 2000 miles from the Magnetic Pole.

TABLE III.—(*Continued.*)

	1848.			1849.			1850.			1851.			Average in 4 years.	Relative number.
	N. C. Officers, Roy. Artillery.	Added by other Observers.	Total Aurora.	N. C. Officers, Roy. Artillery.	Added by other Observers.	Total Aurora.	N. C. Officers, Roy. Artillery.	Added by other Observers.	Total Aurora.	N. C. Officers, Roy. Artillery.	Added by other Observers.	Total Aurora.		
January,	8	3	11	8	...	8	5	4	9	8	3	11	9·7	70
February,	13	1	14	17	...	17	13	6	20	7	6	13	16·	127
March,	13	1	14	11	5	16	12	10	22	15	5	20	18·	159
April,	17	....	17	20	2	22	12	5	17	13	3	16	18·	185
May,	11	....	11	10	7	17	10	3	13	9	5	14	13·7	161
June,	6	....	6	9	3	12	11	6	18	5	3	8	11·	141
July,	9	1	10	12	6	18	17	4	21	7	6	13	15·5	191
August,	6	3	9	8	6	14	15	4	18	8	3	11	13·2	143
September,	7	....	7	12	7	19	16	3	19	12	6	18	15·7	148
October,	14	1	15	12	2	14	17	1	18	12	1	13	15·	124
November,	10	....	10	12	2	14	15	3	18	6	...	6	12·	89
December,	12	1	53	6	4	10	10	2	12	12	1	13	12·	85
	126	11		137	44		154	51		114	42			

The figures in the last column are found by dividing the average of auroras in each month, by the number of hours *less one*, from sunset to sunrise at Toronto (taken as a middle latitude,) on the 15th of that month; they shew in a striking manner the diminished frequency of the phenomenon about the winter solstice, and its great development at the vernal equinox. The returns for the last three months of 1851 are not all collected.

The stations of observation in the first and second groups are not yet numerous enough to decide the question, whether the aurora ever appears in the exterior when it is absent in the interior circles, but in forming an opinion on the number which extend from the interior to the exterior of them, we must not forget that, notwithstanding, the large number of observers, both regular and occasional, in the third group, and their wide distribution, a considerable proportion of the entries in Table III, rest at present upon an observation at only one station,* and *unless particulars are given*, which is unfortunately not always the case, may be reasonably regarded as doubtful. Where particulars are given there can be, of course, no doubt.

The observations made under direction of the Smithsonian Institution begin to be general in March, 1849, and the stations are so numerous that we ought, perhaps, to consider observations to have been possible every night. Table III, has been made as complete as possible, by including some observations kindly communicated by Mr. E. C. Herrick, together with any that were found in the Regent's reports for 1848–1849 of which particulars were given, or which occurred at more than one station on the same evening. Also observations by Mr. Dougald Stewart at Ristigouche, L. C. The few observations at sea at present collected, for most of which we are indebted to Capt. Oliver Eldridge, have not yet been included.

It results from the comparison of the six winter months, October to March inclusive, 1850–1; that aurora was seen before midnight within the first circle on 88·5 per cent. of practicable nights, in the second circle on 80 per cent., and in the third on only 48·5 per cent., indicating a rapid falling off of the causes producing it at distances exceeding 1600 miles from the magnetic pole.

It is scarcely necessary to say that these simple numerical comparisons are but the first fruits of the observations; such as they are, however, they suggest to the mind a spectacle which if true in nature, must be of wonderful magnificence. The polar light kindling on each meridian, as that of day declines, sometimes with the splendor of prismatic coloring over half a hemisphere; sometimes contracting its circles and paling its fires, for a period of days or weeks; and sometimes spreading downwards over the globe, with an intensity of which our highest conceptions are probably inadequate, since, if the region of the display is as elevated as is usually supposed, about a third of its light must be absorbed by the atmosphere. To pursue the subject into all its details would lead me much beyond the limits of such a com-

* Of the total number of 261 observations in 1850, 54 are at one station only; of the total number of 207 in 1851, 71 are at present at one station only—the majority of these in the third group. The proportion to which any doubt can attach is not large.

munication as this; but I am truly anxious to convince any gentleman who may have doubts on the subject, that to keep, in ever so plain a way, a journal of such appearances as may occur at his station, will be a most acceptable contribution to an enquiry which will owe much of its interest and value to the scale on which it is pursued; and especially to induce those to whom I have not the advantage of being personally known, and those resident at the remaining posts in the northern, middle, and extreme western regions to swell the list.

With respect to the influence of these displays upon the movements of the magnetical elements registered by photography at Toronto, I may say that I find the symbols which represent, in the abstract, 'total absence of disturbance,' 'moderate disturbance,' 'considerable disturbance,' and so on, against almost every variety of observation, and am not yet prepared to give any settled opinion on the subject. * * * *

I shall look with much interest for the observations made in the past winter, which in Canada has been remarkable for the number of splendid displays of aurora—and the repeated occurrence of some of the rarest phenomena connected with it, such as the formation of arches of *dark* vapor, of which Mr. C. Campbell has given one instance.

ART. XIX.—*On the Arts and Manufactures of India;* from a Lecture by Prof. ROYLE.*

* * * * As the arrangement of the arts in the jurors' lists and catalogues of the Great Exhibition, though productive of great convenience, is not so well suited for general observations, in consequence of some which are closely allied to each other in their scientific principles being separated from each other, I propose treating of the arts and manufactures of India under the heads of—1. Chemical Arts; 2. Textile Arts; 3. Manual and Mechanical Arts; 4. Fine Arts.

I. CHEMICAL ARTS.—The arts which are strictly chemical may be supposed to have originated only in a country where the science of chemistry had made some advance, but the Hindoos are not usually supposed to have paid any attention to this subject. The Egyptians are thought to have practised, and the Arabs are acknowledged to have been the first who wrote on the subject; but their earliest chemist, Geber, acknowledges that he had only abridged the information to be found in the books of ancient phi-

* From the Lectures on the results of the Exhibition, delivered before the Society of Arts, Manufactures and Commerce, at the suggestion of H. R. H. Prince Albert, President of the Society.

losophers. That the Hindoos were among these, I have attempted to prove in a separate work,* where I have shown the probability of the Arabs having obtained much of their information from Sanscrit works, still in existence.

Chemistry, it has been inferred, must have originated in alchemy; but it appears to me that it must have originated wherever the arts began to be practised: for in seeing the wonderful changes which take place during the action of heat, and some of the most common re-agents, people may easily have been led to believe even in the transmutation of metals.

We know from a variety of sources, that the Hindoos have long been acquainted with many chemical substances, as well as that they have practised many chemical arts. The ordinary metals, including tin, they have long known, and have prepared the oxyds of iron, lead, tin, and zinc. The ashes of plants in a country of wood fires, led them to the discovery of potash. Soda is found effloresced on the soil, as well as crystallized on the margins of some of their lakes. The Arabic name, *sagimen*, indeed, seems to be derived from the Hindoo *saji-noon*, that is, *sajji*, or soda-salt. Nitre must have been produced then, as now, in their soil, and borax imported from Tibet, while sal-ammoniac must have been produced ever since they made bricks, as they now do. Alum they obtain by throwing potash on alum slate, which has been some time exposed to the air. Among the salts of the metals, we find the sulphates of copper, of zinc, and of iron, the acetates of copper and of iron, and the carbonates of lead and of iron. They seem, also, to have been long acquainted with the three mineral acids, for making which they have peculiar formulæ, while their lemons and limes gave them citric, and the gram-plant (*Cicer arietinum*) the oxalic acid.

It is evident, therefore, that the Hindoos possessed many chemical substances, and that they prepared others; hence we might infer that they may have practised some of the chemical arts, as, indeed, we know they must have done from other sources. But this would equally prove that they must have possessed various chemical substances, whencesoever obtained.

Pharmaceutical Products.—In the present state of the chemical arts, advanced as they have been by the cultivation of the science in Europe, it was not to be expected that such products as are obtained by the natives of India, by their original and primitive processes, could be sent to the Exhibition with any hope of attracting attention. Few, therefore, have been sent from the bazaars of India, except as curiosities. But there are others, prepared under European superintendence for the use of the public service, which are excellent in quality; and I know

* "Essay on the Antiquity of Hindoo Medicine."

not why India might not under such superintendence prepare some that might become articles of commerce: such, for instance, as benzoic and citric acids, the salts of morphia, narcotin as an efficient substitute for quinine in a number of cases; with some extracts and tinctures of substances which lose their effect by transmission and the influence of physical agents.

The sulphate of magnesia is interesting as prepared from magnesite or the natural carbonate of magnesia of the Peninsula.

Metallurgy.—Though it is difficult to understand how a primitive people could have overcome the difficulties of smelting iron and of forging steel, yet as we know from a variety of sources that the Hindoos have long known both, they must have overcome the difficulties which have stopped others. But it is hardly less wonderful to see a native with no other tools than his hatchet and his hands proceed to smelt iron, which he will convert into steel capable of competing with the best prepared in Europe. For this the prevalence of the black oxyd of iron, in the state of iron sand, and the common use of charcoal as a fuel, give him some facilities, while he prepares a furnace with clay, and makes bellows with the leaves of the forest. [Of this last, a specimen was shown from the hills of Mirzapore.]

Iron and steel, though not known in the earliest periods of the history of some of the civilized nations of antiquity, have yet been known from very early periods. Iron is mentioned as being applied to a variety of purposes in the earliest chapters of the Bible. But as it is too soft to be used for all the purposes stated, it has been justly inferred that they must have known of modes of hardening it, and reference is made to that kind which is called "northern iron." But as the term of "northern" is also applied to the roads of commerce and of conquest from the East, because these entered Judæa by the north, that is, by way of Damascus and Syria, so Mr. Aikin looks to the countries east of Babylonia as those where this hard iron and steel was produced; and this is confirmed by the passage in Ezekiel, where Dan and Javan are described as bringing "bright iron, cassia, and calamus," which are all Indian products, to Tyre.

The Hebrew name of steel, *paldah*, is evidently the same word as the Arabic *foulad*, which is also in use in Persia, where Indian steel is known by the name of *foulad-i-hind*. Even now the best Persian swords are made with steel imported from India, and Mr. Wilkinson has ascribed the markings on the famed Damascus blades to their having been made with Indian steel, which has long formed an article of trade from Bombay to the Persian Gulf.

Mr. Heath, at one time the managing director of the India Iron and Steel Company, and whose steel obtained a prize at the Exhibition, even says, "We can hardly doubt, that the tools with

which the Egyptians covered their obelisks and temples of porphyry and syenite with hieroglyphics, were made of Indian-steel." There is no doubt, that the ancient Indian temples and fortresses were carved with steel instruments, as they are at the present day. That they made steel which was highly valued in the time of Alexander the Great, is evident from Porus making him a present of about thirty pounds of steel; and still earlier, in the Rig Veda, we read of chariots armed with iron weapons, of coats-of-mail, arms and tools of different kinds, and of bright-edged hatchets.

Various descriptions of the manufacture of iron and steel have been given by observers in different parts of India; all of which bear a considerable resemblance to each other. Some of these Mr. Aiken carefully noticed when he lectured on this subject in this very place; but Mr. Heath has, I think, given the best explanation of the Indian processes.

Mr. Heath describes the ore used as the magnetic oxyd of iron, consisting of seventy-two per cent. of iron with twenty-eight of oxygen, combined with quartz, in the proportion of fifty-two of oxyd to forty-eight of quartz. It is prepared by stamping, and then separating the quartz by washing or winnowing. The furnace is built of clay alone, from three to five feet high, and pear-shaped; the bellows is formed of two goat-skins, with a bamboo nozzle, ending in a clay pipe. The fuel is charcoal, upon which the ore is laid, without flux; the bellows are applied for four hours, when the ore will be found to be reduced: it is taken out, and while yet red-hot, it is cut through with a hatchet, and sold to the blacksmiths, who forge it into bars and convert it into steel. In an old account which I possess, written on the spot, apparently in Mysore, it is said, that one pound and a half of iron is heated lower than red heat, and then beaten for about three minutes with a stone hammer on a stone anvil, experience having taught them, they say, that instruments of iron ruin the process. Mr. Heath says that the iron is forged by repeated hammering, until it forms an apparently unpromising bar of iron, from which an English manufacturer of steel would turn with contempt, but which the Hindoo converts into cast steel of the very best quality. To effect this he cuts it into small pieces, of which he puts a pound, more or less, into a crucible, with dried wood of the *Cassia auriculata*, and a few green leaves of *Asclepias gigantea;* or, where that is not to be had, of the *Convolvulus laurifolia*. The object of this is to furnish carbon to the iron.

As soon as the clay used to stop the mouths of the crucibles is dry, they are built up in the form of an arch in a small furnace, charcoal is heaped over them, and the blast kept up without intermission for about two hours and a half, when it is stopped,

and the process considered complete. The furnace contains from twenty to twenty-four crucibles. The crucibles are next removed from the furnace and allowed to cool; they are then broken and the steel taken out. The crucibles are formed of a red loam, which is very refractory, mixed with a large quantity of charred husk of rice.

Mr. Heath, after remarking the astonishing fact that the Hindoos had discovered the way of making steel at such early periods, refers to Mr. Mushet's discovery of converting iron into cast steel by fusing it in a close vessel, in contact with any substance yielding carbonaceous matter, and then to that of Mr. Mackintosh, of converting iron into steel, by exposing it to the action of carburetted hydrogen gas in a close vessel at a very high temperature, by which means the process of conversion is completed in a few hours; while by the old method it was the work of from fourteen to twenty days. Mr. H. observes:—

"Now, it appears to me that the Indian process combines the principles of both the above described methods: on elevating the temperature of the crucible containing pure iron and dry wood and green leaves, an abundant evolution of carburetted hydrogen gas would take place from the vegetable matter, and as its escape would be prevented by the luting at the mouth of the crucible, it would be retained in contact with the iron, which at a high temperature appears from Mr. Mackintosh's process to have a much greater affinity for gaseous than for concrete carbon: this would greatly shorten the operation, and probably at a much lower temperature than even the iron in contact with charcoal powder. In no other way can I account for the fact that iron is converted into cast steel by the natives of India in two hours and a half, with an application of heat that in this country would be considered quite inadequate to produce such an effect; while at Sheffield it requires at least four hours to melt blistered steel in wind furnaces of the best construction, although the crucibles in which the steel is melted are at a white heat when the metal is put into them, and in the Indian process the crucibles are put into the furnace quite cold."

By such simple methods the Hindoo prepared steel, which has long formed an article of commerce from the west of India to the Persian Gulf, and there is every probability of its being used in larger quantities if it were easily procurable in sufficient quantities, as manufacturers here have expressed a desire to employ it. In the arms which we have exhibited, as well as in the edges and points of the tools, we see its admirable fitness for the fabrication of all cutting instruments.

Among the arms we have a display of such as would appear to belong to different ages of the world, but which are actually in use in India at the present day; such as chain and scale ar-

mor, both for man and horse, helmets and shields, spears, battle-axes, bows and arrows, with daggers in every variety. Some of these display in a remarkable manner their skill as cutlers; as, for instance, the sword formed of two blades, and another in which pearls are let into the centre of its blade; and still more in the daggers contained one within another, all of hard steel, with the line of junction so beautifully welded as to be hardly perceptible even with a magnifier,—so also in the dagger, which on striking separates into five blades, as these are most nicely brought into juxtaposition. The twisting of gun-barrels and the damasks of their blades of steel have been imitated in all countries. These beautiful specimens have been sent chiefly by the native princes of the northwest of India from Putteala to Scinde, as well as from the central government of Hyderabad.

The other metal which it seems necessary to mention is tin, because connected with so many metallurgical compounds, and because by many it has been supposed that this country was the only source from which that metal was obtained in ancient times. But it exists in large quantities in the Malayan Peninsula, as well as in Banca, Borneo, and many other islands. Tin, we know, was employed by the Egyptians, because it forms an ingredient in some of their metallic compounds; but its use has long been familiar to the Hindoos for forming various metallurgical compounds, as well as for tinning copper. As it occurs as an oxyd, and near the surface of the soil in large quantities, and requires only charcoal for reducing it, we may suppose it would easily have been discovered by a people who forged iron and made steel. As the nations of antiquity employed tin for hardening copper, and used the alloy for forming swords and spear-heads, so the natives of India form various compounds with copper and tin, which are remarkable for their hardness, and for the fine sounds which they emit on being struck. Dr. Wight lately found that an alloy of ten grains of copper to two and a half grains of tin was the best mixture which a native made in his presence. British spear-heads are found to consist of one of tin to ten of copper, and a knife, of one of tin to seven and a half of copper. Mr. Aikin, in his experiments, found that eight grains of copper to one of tin formed the hardest alloy.

Alloys.—The natives of India are acquainted with a variety of alloys for making utensils and even ornaments, as with copper and zinc, tin and lead, besides being great workers in copper and brass for the various utensils employed for domestic purposes, and of which so large a variety was sent from different parts of India.

Bidery.—A metallurgical compound of considerable interest is that which has been named Bidery, from Bider, a city situated about sixty miles to the north-west of Hyderabad, and of which

we have had a variety of articles at the Exhibition. Most of these have been greatly admired for the elegance of their form, as well as for the gracefulness of the patterns with which their surface is engraved. Though the groundwork of this composition appears of a blackish color, its natural color is that of pewter or of zinc. Dr. Heyne informs us that it is composed of copper sixteen ounces, lead four ounces, tin two ounces. These are melted together, and to every three ounces of the alloy sixteen ounces of spelter, that is of zinc, is added, when the alloy is melted for use. But to give the whole the black color which is esteemed, probably from bringing out the pattern, it is dipped into a solution of sal-ammoniac, saltpetre, common salt, and blue vitriol.

Dr. B. Hamilton saw of zinc 12,360 grains, copper 460 grains, and lead 414 grains, melted together, and a mixture of resin and bees-wax introduced into the crucible to prevent calcination. It was then poured into a mould made of baked clay, and the article handed over to be turned in a lathe. Artists then inlay flowers or other ornaments of silver or of gold. They first rub it over with sulphate of copper and water, which gives the surface a blackish color, and enables the artist more easily to distinguish the figure which he draws,—this he does with a sharp-pointed instrument of steel, and cuts it with small chisels of various shapes, and then with a hammer and punch fills the cavities with small plates of silver, which adhere firmly to the Bidery. It is then polished and stained as described above. The various articles made from it are vases, wash-hand basins and ewers, hookah-bottoms, spittoons, cups and dishes, small boxes and weights. These are inlaid commonly with silver, but sometimes with gold. The patterns are usually as much to be admired as the forms of the vessels. Though usually called Bidery, sometimes Vidry, it is also manufactured at others places. Specimens have been sent both from Bider and Aurungabad, in the Nizam's territories, from his Highness the Nizam and his minister, Siraj-ool-Moolk, which are peculiarly beautiful. Some also from north-west India, and from Bengal; the latter, however, was inferior to the others in workmanship. Bidery does not rust, yields little to the hammer, and breaks only when violently beaten. According to Dr. Hamilton it is not near so fusible as zinc or tin, but melts more easily than copper.

Glass.—Glass is one of those discoveries which could hardly escape being made by any people who employed furnaces to reduce metallic oxyds; for the necessary ingredients must often have been present, and the heat was sufficient. Beckmann has observed, that the discovery of colored glass must have followed very soon that of making glass itself. It is probable, however, that colored glass was made previous to colorless glass. For it is

difficult to find materials pure enough to make good glass, and it would be some time before the original makers would find out the causes of discoloration.

The natives of India seem to have been long acquainted with making different ornaments of glass: for instance, armlets and anklets, while rings of glass form a part of their warping reels. Small glass bottles are also made; but all that I have seen are of a more or less greenish color. The green is called *kanch*, and the purer glass, *sisi*. It is probable that the extensive diffusion of oxyd of iron in the Indian soil, which may have led to the discovery of iron, has prevented the making both of good glass and of good pottery. That this is not incompatible with a knowledge of the method of making imitation gems, seems proved by the same having been the case in the time of Pliny; who states that great value was set upon glass quite free from color, which was called crystal. He also mentions artificial hyacinths, sapphires, and all kinds of black glass; and we know that the glass-houses of Alexandria were celebrated among the ancients.

One of the simplest processes for making glass is that practised in the district of Behar. The saline efflorescence of the soil, which is an impure carbonate of soda, is collected and thrown into a cistern lined with clay. This is then filled with water, which is afterwards allowed to evaporate. When dry, the bottom of the cistern is found covered with a thick saline crust, the earth which was intermixed having subsided before the salt began to crystallize. This soda makes glass without any addition, as it still contains a sufficient portion of siliceous matter. They make blackish and greenish glass: a bright grass-green is made by additions of oxyd of copper; and a blue glass by the addition of *rung*. In Mysore the process is more elaborate. Powdered white quartz, one part, being mixed with prepared soda, six parts, is filled into a crucible capable of containing five and a half Winchester gallons. About fifty of these crucibles are placed in a furnace, and the fire kept up for five days, when a frit is produced, with which they make a black, green, red, blue, and yellow glass, by means of additions of oxyd of copper, of an ore called *kemudu*, and of a blue substance called *runga*. What these are I have not been able to discover. Though the making of glass has made but little advance in India, the natives work up broken English glass even into barometer and thermometer tubes, &c. Glass globes, silvered in the inside, were sent from Delhi, but unfortunately got broken in the transmission. The mode of effecting this silvering is not mentioned, but an amalgam of quicksilver is probably employed, as, on the application of moderate heat, the silvering becomes dissipated. An art similar to this has of late years been discovered in this country.

Enamelling.—Enamelling, or the art of fixing colors by melting in fire, is of very ancient date: it was practised by the Egyptians, and carried to a high degree of perfection in Persia. The art is known in every part of India, and some exquisite specimens were sent to the Exhibition, both from Central and North-western India. It is chiefly employed in ornamenting arms and jewellery, not only in gold, but also in silver.

Enamels being vitrifiable substances, to which peculiar colors are given, we may compare the Indian with the European methods of making enamel. In general, ten parts of lead and three parts of tin are oxydized by continued heat and exposure to air. To the mixed oxyds add ten parts of powdered quartz, and ten parts of common salt, and melt in crucibles. Thus is obtained a white enamel, and the basis of colored enamel, metallic oxyds being added. The oxyd of lead or of antimony produces a yellow enamel: reds are obtained by a mixture of the oxyds of gold and iron. The oxyds of copper, cobalt, and iron, give greens, violets, and blues; and a variety of intermediate colors by mixtures. The workmen of Behar are stated to make two enamels, which are applied to the surface of some of the rings. One is yellow: five parts of lead are melted in a shallow crucible, and to these is added one part of tin; and the alloy is calcined for four or five hours. It is then heated to redness in the crucible of the glass-furnace. One part of white quartz is next added, and the mass stirred about for three hours. It is then taken out with a ladle, poured out on a smooth stone or iron, and cooled in water. They then take one part of their palest green glass, and add a fourth part of the other materials, to make the yellow enamel.

The green enamel is made in the same manner; and to the melted glass is added, not only the prepared lead and tin, but a small portion of the black oxyd of copper.

In Mysore they make a bright yellow enamel, by first calcining five parts of lead and one of tin, then adding one part of zinc, calcined in a separate crucible. When these begin to adhere they are powdered in a mortar. When the maker of glass rings is at work, he melts some of this powder, and while the ring is hot, with an iron rod applies some of it (the powder) to the surface of the glass.

Pottery, Encaustic Tiles, Cement.—The art of fashioning clay into vessels of a variety of shapes, and hardening it by the action of heat, is one of the most ancient of the arts. Fragments of pottery are everywhere found among the ancient cities of India, as in those of other parts of the world; pottery, as Brongniart has remarked, affording the best record of the early ages of man, as bones do of the earth.

So little is known of Indian pottery, that it is usually described as being hemispherical in shape. Some of it is no doubt so, for the convenience of being carried on the head; but it is a fact, that in the recent exhibition of Indian pottery, numbers of the best judges have greatly admired its elegant, even classical gracefulness of form. It is also stated to be black, and red, or yellowish. The clays which are generally employed in the more populous parts of the country, Dr. O'Shaughnessy has observed, "contain so much oxyd of iron and carbonate of lime that the vessels melt into a slag at a temperature little above that of redness." "Deposits of a black stiff clay, containing much vegetable matter, occur in some districts; vessels made with it sustain a higher temperature." Clays capable of bearing great degrees of heat have, however, been discovered in different parts of India. As one great object is to have porous vessels for cooling water, the ordinary clays answer sufficiently well for this purpose; and some of the forms, as that of the tortoise-shaped, expose a large surface to the air. The Hindoos, moreover, never use a vessel a second time, so no great expense will be incurred by them; thus encouragement is wanting to improve the nature of their pottery. But very successful experiments have been made to make improved pottery in India, as by Mr. Julius Jeffreys, the ingenious inventor of the respirator, who succeeded in making stone-ware soda-water bottles, crucibles, fire-bricks, tiles, &c., which seem to have been glazed by the silica uniting with the alkaline ashes of the furnace. Dr. O'Shaughnessy greatly improved the pottery in use in the dispensary of Calcutta, and which he glazed with the borate of lime. The glazed pottery of Pegu, of which two very large jars were sent, has long been known for its glaze not being affected by acids. Dr. Hunter has sent some excellent specimens of pottery from the School of Arts at Madras, and for which a prize has been awarded.

The ancient potter's wheel is the instrument with which the Hindoo works; and while it revolves, with the aid of his naked hands he fashions vessels of elegant forms, many of which have been admired as being of classical shapes, and some would appear almost as if they were of Etruscan origin: but there is no reason to believe that the Hindoos have ever had anything but their own unerring taste to guide them. This beauty of form is equally conspicuous in the pottery of Sewan near Patna, as in that of Azimgurh or of Ahmedabad, of Mirzapore, or of Moradabad.

Some of it is remarkable, also, for its extreme thinness and lightness, showing the great skill of the artist, and making it difficult to understand how it kept its shape when in a plastic state, as I cannot learn that the turning lathe is used to give a finish to any of the articles. The painted pottery of Kotah, and the gilt

pottery of Amroha, have also been admired. The handles and the various ornaments of the Ahmedabad pottery are no doubt attached, as in Europe, by means of slip. From the specimens of basket-work pottery sent, there is no doubt that, with better materials and a little instruction, the natives could excel in this as in the forms of their pottery.

If we had no other information, we might yet infer from the crucibles employed by the goldsmith, by the workers in brass, and by the makers of cast steel, that some very infusible clays are to be found in India; but recent investigations have proved that crucibles and fire-bricks, superior in infusibility to those made of Stourbridge clay, have been made in India; and from the white goblets of Arcot, and the light-colored pottery of Madras, as well as from the white bricks sent from the Ceded Districts, we see that there are many useful clays without the usual admixture of iron.

As connected with pottery might be mentioned the variously colored *Encaustic* tiles, which have been used for the domes of some of the tombs near Delhi and Agra, as well as in Southern India; but I cannot learn that the art is at present practised. It was probably introduced by the Mahomedans from Persia. Specimens from some of these tombs were shown by Mr. Boileau.

I might have proceeded to notice their knowledge of *Cements*, but I may in preference notice a kindred art, which seems capable of adoption elsewhere when suitable; that is, the skill with which they give a facing of marble to a wall of brick. This they usually do by employing mortar made of shell-lime; but I found some made from pure limestone equally good. A thin layer of this fine white cement being spread, is brought to the lustre of marble by a process similar to burnishing.

Bleaching.—Bleaching is practised in all parts of India, and some places, which are also seats of the cotton manufacture, are famous for bleaching, such as Dacca and Baroche. This has been ascribed to the excellency of the water in the neighborhood of these places. A very good account has been given by Mr. Taylor,* late of Dacca, of the process of bleaching at that place. This is particularly interesting, as including what are called modern discoveries.

Fine muslins are merely steeped in water; other cloths are first washed: but all, of whatever texture they may be, are next immersed for some hours in an alkaline ley composed of soap and of sajie muttee, that is, impure carbonate of soda. They are then spread over the grass, and occasionally sprinkled with water, and when half dried are removed to the boiling-house in order to be steamed. This is effected by twisting the cloths into the

* "An Account of the Cotton Manufacture in Dacca," &c. Published by Mortimer.

form of loose bundles and placing them upon a broad clay platform, which is on a level with, and surrounds, the neck of a boiler sunk into the ground. They are then arranged in circular layers, one above the other, around a bamboo tube, which is kept upright by means of transverse supporters projecting from it, the whole forming a conical pile that rises to a height of five or six feet above the boiler.

The fire is kindled in the excavation below, and as the ebullition of the water proceeds, the steam diffuses itself through the mass of the cloths above, swelling by its high temperature the threads of the latter. The operation of steaming is commenced in the evening, and continued all night till the following morning. The cloths are then removed from the boiler, steeped in alkaline ley, and spread on the grass as on the preceding day, and again steamed at night. These alternate processes of *bucking* and *crofting*, as they are technically called, during the day, and of steaming at night, are repeated for ten or twelve days, until the cloths are perfectly bleached. After the last steaming, they are steeped in clear filtered water acidulated with lime-juice, in the proportion, generally, of one large lime to each piece of cloth. Lime-juice has long been used in bleaching in all parts of India, and Tavernier describes Baroche as famous as a bleaching station, on account of its extensive meadows and the large quantity of lemons reared there.

Mixed fabrics of cotton and Muga silk are steeped in water mixed with lime-juice and coarse sugar, which later article is said to have the effect of brightening the natural color of the silk.

Dyeing, Calico-printing, and Printing in Gold.—The art of dyeing is no doubt of very ancient date, and one with which the Hindoos have long been well acquainted. Their country produced all the raw materials for making a great variety of colors; some of these are of so conspicuous a nature, such as the large flowers of plants, that the desire must early have occurred to transfer these colors to the person in savage nations, or to the clothes of so early civilized a people as the Hindoos. This could easily have been done with the fugitive colors, but as they know how to make a color like that of indigo, which undergoes a considerable degree of chemical change during its formation as well as while applied to the dyeing of its blue color, it is evident, even if we had no other information on the subject, that they must have paid attention to some chemical subjects. But we know that they have long possessed, and knew how to manufacture, the several salts which have long been employed as mordants.

That the art of dyeing was early practised we have proof in the fact mentioned by Pliny, that flags of various colors were displayed by the Indians. It has been supposed that the Hindoos may have learned this art from the Egyptians, but the prob-

ability is as great that the latter learned the art from the former, from whom also they probably obtained the alum which was celebrated by the name of Egyptian alum. Alum is still manufactured in Cutch; the natives of India have long known the use of sulphate of iron and acetate of iron. The latter they prepare by macerating iron in sour palm-wine, or in water in which rice had been boiled. The alkalies and acids with which they are acquainted may have assisted them in changing the shades of colors. It would take too much time to enter into the details of these dyeing processes, many of which are, however, now well known, and seem to have been the original of many of those followed in Europe until very recent times. The Exhibition has shown that they can dye every color, and of a great variety of shades, and that, in a complicated pattern, they know the value and power of each in contrasting the effect of others, so as to produce an harmonious whole.

The art of *Calico-printing* is another of those which was common to the Egyptians and Indians, and is still largely practised by the latter, and with a skill which produced much to be admired even in the midst of the productions of the world, and after so many attempts have been made to improve an art certainly imported from the East. Pliny was acquainted with the wonderful art by which cloths, though immersed in a heated dyeing liquor of one uniform color, came out tinged with different colors, and which afterwards could not be discharged by washing. The Indians were found practising the art when first visited by the Europeans. The mordants they apply both by pencils and by engraved blocks, though it has been said that the former method was the only one employed. Blocks were sent from Cossipore, and are used in Mysore and in Central India; some specimens of silk handkerchief were exhibited by Mr. Warrington, to show the different stages of dyeing as practised in India. In one, the parts where the round spots were to be, were tied up with thread so as not to be affected by the dye-liquor.

The cloth-printers at Dacca are employed to stamp the figures on cloth which is to be embroidered. The stamps are formed of small blocks of khutul (*artocarpus*) wood, with the figures carved in relief. The coloring matter is a red earth imported from Bombay, probably the so-called "Indian earth" from the Persian Gulf.

Though the art is now practised to such perfection in this country, the Indian patterns still retain their own particular beauties, and command a crowd of admirers. This no doubt is due in a great measure to the knowledge which they have of the effects of colors, and the proportion which they preserve between the ground and the pattern, by which a good effect is procured both at a distance and on a near inspection.

Printing in gold and in silver is a branch of the art which has been carried to great perfection in India, judging by the several specimens sent from very different parts of India, as well upon thick calico as upon fine muslin. The size which is used I have not found mentioned, but in the Burmese territory the juice of a plant is used, which, no doubt, contains caoutchouc in a state of solution.

Leather is another chemical art with which the Hindoos have long been acquainted, though it is doubtful whether they ever made leather of very superior quality; but the art is practised in native states where it is not likely to have been introduced by European influence, as, for instance, in Cashmere and Cutch, whence we have had skins dyed of different colors. But leather of very excellent quality has been sent from the government farm at Hoonsoor in Mysore, likewise from Calcutta by the Messrs. Teil. The native shields are, however, not to be surpassed.

Soap seems to have been introduced by the Mahomedans, though the Hindoos have long used alkaline leys, obtained from the ashes of plants, for many of the purposes of soap; and they have a substitute for soap in several berries. Soap is made at Dacca, of shell lime, 10 mds.; sajie muttee, 16 mds.; common salt, 15 mds.; sesamum oil, 12 mds.; goats' suet, 15 seers. It is made of good quality at Saharunpore; and some marine soap, of excellent quality, though in small quantity, was sent from Calicut.

Candles may be appropriately mentioned here, though the mode of making them is probably not Indian, but taught by Europeans. The natives use oil lamps, of various shapes, often of metal fixed on an iron spike, which they stick into the ground. But excellent candles are now made in India; as, for instance, the wax candles from Patna, and the stearic candles of the Messrs. Sainte from Calcutta.

Lacquer Ware.—The word *lacquer* is evidently derived from the Indian name *lac* or *look*, which is the resin secreted together with lac-dye by the lac insect, a species of *coccus*. The name occurs in Avicenna, who mentions it, as described by some, as the gum of a tree like the myrtle, and by others as a substance like to, and having some of the properties of amber. It is mentioned in many Indian works, and is apparently alluded to by Ctesias. This substance is used for a variety of purposes in India, and it is the common material for uniting things together, as gum and glue are in Europe. (Toys of various kinds, lac chains gilt, and lac grindstones, were shown.)

The term *lacquer* is applied to laying on or covering with a preparation of lac; but two different processes are usually confounded under this term. The one prevailing in Burma and the southern parts of the Indian Peninsula was well known to Dampier, in 1638, as he says, "The lac of Tonquin is a sort of

gummy juice which drains out of the bodies or limbs of trees," and that "the articles lackered are cabinets, desks, &c." Some chemical change, no doubt, takes place on exposure of these juices to the air.

This kind of lacquered ware was much appreciated in the last century, and was imported chiefly from China; much, however, was always prepared in Burma, though that of Japan was always considered superior to any other, and of which many fine specimens may still be seen in large folding screens, &c. Both these and the lacquer of Burma are prepared only from the juice of a family of plants, (the *Terebinthaceæ*,) the same as that to which the marking nut and sumach belong.

The chief expense of the manufacture arises from the care with which successive layers of varnish must be laid on. Various specimens of boxes have been sent from Moulmein and from Singapore, some showing different stages of the process.

Another kind of lacquer-work is rather of the nature of papier-mâché, covered with one or more layers of lac varnish. This is the case with the lacquered boxes from Cashmere and Lahore, so remarkable for the beauty and elegance of their patterns.

Sealing-Wax is also made from lac, and several varieties have been sent from different parts of India. Garcias ab Orto described it as made from lac in the year 1563. Tavernier mentions the same fact. The Spaniards have obtained credit for the invention; but they, no doubt, learned it from the Arabs. A Frenchman who travelled much in Persia and different parts of the East Indies is also thought to have been the discoverer; and by Beckmann it is considered to be a German invention. This is hardly a chemical art, but it is probably better placed here than elsewhere.

Paper.—The art of making paper is considered to be a Chinese invention, but it has long been known in India, where paper is made both of cotton and of the substitutes for hemp and flax. In the Himalayas it is made of the inner bark of *Daphne cannabina*, and in sheets of immense size. A large collection was exhibited from different parts of India, but, though well adapted for writing on in India, it is not suited for Europe, in consequence of the difference in the ink used.

(*To be continued.*)

ART. XX.—*Abstract of a Paper on the Humite of Monte Somma;* by ARCANGELO SCACCHI,* of Naples, with observations, by JAMES D. DANA.

M. SCACCHI in his elaborate paper points out the fact that there are three types of crystals of Humite. These several forms he illustrates by excellent figures both of simple and compound crystals, and with full crystallographic descriptions mathematically deduced.

The crystals of the different types agree in general similarity of form, even to the relative positions of the series of planes, as shown in the following figures I, II, III, yet they differ in these series, and in the inclinations of homologous faces. This difference corresponds to a difference in the lengths of the vertical axis, the ratio of the two lateral axes being nearly identical. The form is trimetric and the ratios of the axes as deduced by M. Scacchi, (n^2 in I and II, and n^4 in III, being taken as a face of the fundamental form) are as follows:—

	a :	b	: c		a	: b :	c
I.	1 :	0·245315	: 0·227101	[which equals	4·0764	: 1 :	0·92575]
II.	1 :	0·343769	: 0·318435	[" "	2·9090	: 1 :	0·92631]
III.	1 :	0·190730	: 0·176465	[" "	5·2430	: 1 :	0·92520]

In the latter expression of the ratios, which we have here added, the similarity in the several ratios, $b : c$, is apparent; the mean of the three is, 1 : 0·92575. The ratio between the vertical axis for the three types, as M. Scacchi states, is 7 : 5 : 9, that is, $3\cdot3\frac{1}{3}\frac{1}{13} : 3\cdot3\frac{1}{3}\frac{1}{7\,6\,3} : 3\cdot1\frac{1}{7}\frac{1}{3\,6} = 4\cdot0764 : 2\cdot9090 : 5\cdot2430 = 7 : 5 : 9$.

This ratio according to M. Scacchi, represents the true relation of the types, and the three forms are therefore spoken of as probable examples of a kind of dimorphism, or pleomorphism: for where the same chemical compound crystallizes in forms so widely different in normal dimensions, they are properly regarded as distinct forms, though all three may belong to the same crystallographic system.

The mathematical relations of the planes as developed by M. Scacchi are of unusual interest. There is a regular succession in the exponents of the planes like parts of a geometrical series, which are different for the different types. On this account we are led to cite the symbols for the planes at length. These symbols are given by the author, both in accordance with the view of three types, and based on the axes above mentioned; and also on the ground that all belong to one type instead of three.

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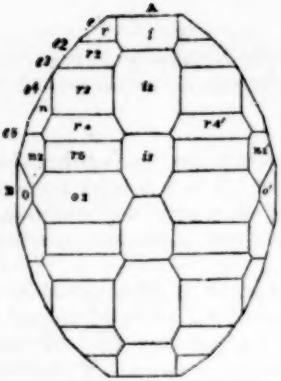
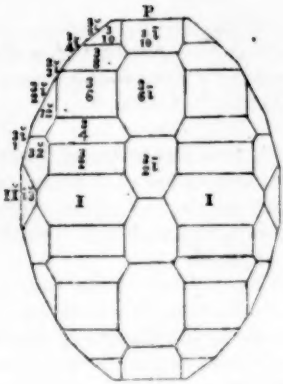
* Poggendorff's Annalen, 1851, Ergänzung, iii, 161.

I.



A.



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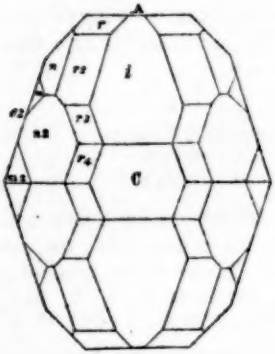
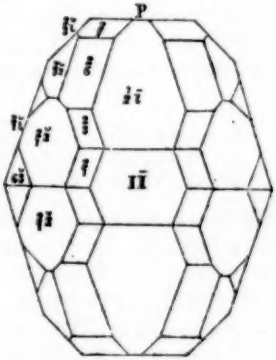
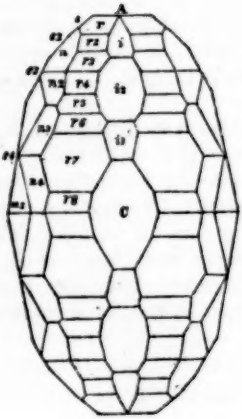


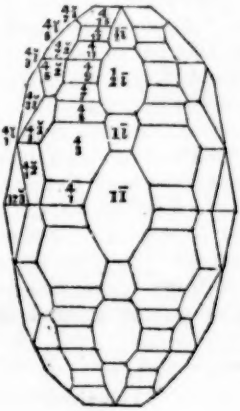
B.



III.



C.



The axes deduced for the common type are

$$a : b : c = 1 : 1{\cdot}7172 : 1{\cdot}5897.$$

The following are the symbols for type I (fig. I), based upon these axes:

e	$= 1 : \frac{5}{7} : \infty$	n	$= 1 : \frac{3}{7} : \frac{3}{7}$	r	$= 1 : \frac{10}{7} : \frac{5}{7}$	i	$= 1 : \infty : \frac{5}{7}$
e^2	$1 : \frac{4}{7} : \infty$	n^2	$1 : \frac{1}{7} : \frac{1}{7}$	r^2	$1 : \frac{8}{7} : \frac{4}{7}$	i^2	$1 : \infty : \frac{3}{7}$
e^3	$1 : \frac{3}{7} : \infty$			r^3	$1 : \frac{6}{7} : \frac{3}{7}$	i^3	$1 : \infty : \frac{1}{7}$
e^4	$1 : \frac{2}{7} : \infty$			r^4	$1 : \frac{4}{7} : \frac{2}{7}$		
e^5	$1 : \frac{1}{7} : \infty$			r^5	$1 : \frac{2}{7} : \frac{1}{7}$		

The symbols for the three figures, based on the hypothesis of three types and the axes given above, are as follows. The numbers in the ratios are the coefficients of the axes $a : b : c$ for each form.

	I.	II.	III.
e	$1 : 5 : \infty$	$1 : 3 : \infty$	$1 : 7 : \infty$
e^2	$1 : 4 : \infty$	$1 : 1 : \infty$	$1 : 5 : \infty$
e^3	$1 : 3 : \infty$		$1 : 3 : \infty$
e^4	$1 : 2 : \infty$		$1 : 1 : \infty$
e^5	$1 : 1 : \infty$		
n	$1 : 3 : 3$	$1 : 3 : 3$	$1 : 7 : 7$
n^2	$1 : 1 : 1$	$1 : 1 : 1$	$1 : 5 : 5$
n^3			$1 : 3 : 3$
n^4			$1 : 1 : 1$
r	$1 : 10 : 5$	$1 : 7 : \frac{7}{2}$	$1 : 15 : \frac{15}{2}$
r^2	$1 : 8 : 4$	$1 : 5 : \frac{5}{2}$	$1 : 13 : \frac{13}{2}$
r^3	$1 : 6 : 3$	$1 : 3 : \frac{3}{2}$	$1 : 11 : \frac{11}{2}$
r^4	$1 : 4 : 2$	$1 : 1 : \frac{1}{2}$	$1 : 9 : \frac{9}{2}$
r^5	$1 : 2 : 1$		$1 : 7 : \frac{7}{2}$
r^6			$1 : 5 : \frac{5}{2}$
r^7			$1 : 3 : \frac{3}{2}$
r^8			$1 : 1 : \frac{1}{2}$
m		$1 : \frac{5}{3} : \frac{5}{3}$	$1 : 3 : \frac{3}{2}$
m^2		$1 : \frac{1}{3} : \frac{1}{2}$	$1 : \frac{1}{3} : \frac{1}{2}$
i	$1 : \infty : 5$	$1 : \infty : 2$	$1 : \infty : 6$
i^2	$1 : \infty : 3$		$1 : \infty : 4$
i^3	$1 : \infty : 1$		$1 : \infty : 2$

The relation of the general and special symbols for fig. I, will be at once seen on comparison: they differ only in that the former have for the value of b and c, the quantities in the latter divided by 7. In the same manner, the divisor for figure II will be 5, and

for figure III, 9. By keeping this in view, the general symbols are easily deduced and need not be here repeated: (e. g., for r in fig. III, the special symbol is $1 : 15 : \frac{1}{2}^5$, and hence the general symbol will be $1 : \frac{1}{2}^5 : \frac{1}{1}\frac{5}{5}$; for m^2 the special symbol is $1 : \frac{1}{3} : \frac{1}{2}$, and therefore the general symbol is $1 : \frac{1}{2}\frac{1}{1} : \frac{1}{1}\frac{1}{2}$).

The following are some of the angles obtained by M. Scacchi, calculating from the dimensions of the common type.

Type I, (fig. I.)—A on i 138° 38′, on i^2 124° 16′, on i^3 102° 48′.
A on r 135° 52′, on r^2 129° 30′, on r^3 121° 44′, on r^4 112° 24′, on r^5 101° 39′.
A on n 116° 34′, on n^2 99° 28′.
A on e 140° 49′, on e^2 134° 28′, on e^3 126° 21′, on e^4 116° 08′, on e^5 103° 47′.
B on o 144° 14′, on o^2 114° 50′.

Type II, (fig. II.)—A on i 122° 27′.
A on r 135° 17′, on r^2 125° 48′, on r^3 113° 24′, on r^4 98° 13′.
A on n 125°, on n^2 103° 8′.
A on m 114° 55′, on m^2 95° 19′.
A on e 135° 51′, on e^2 108° 58′.

Type III, (fig. III.)—A on i 136° 40′, on i^2 125° 14½′, on i^3 109° 27′.
A on r 140° 15′, on r^2 136° 11′, on r^3 131° 24′, on r^4 125° 48′, on r^5 119° 17′, on r^6 111° 50′, on r^7 103° 31′, on r^8 94° 35′.
A on n 132° 13′, on n^2 122° 57′, on n^3 111° 15′, on n^4 97° 23′.
A on m 114° 55′, on m^2 92° 57′.
A on e 143° 10′, on e^2 133° 39′, on e^3 119° 47′, on e^4 100° 48′.

Passing by, for the present, other details in the admirable paper of M. Scacchi, we proceed to a few remarks on another mode of viewing these crystals and to some deductions therefrom.

The difficulty in referring the three dissimilar types to a common fundamental form or to forms approximately identical, arises from the fact that the three crystals have no planes in common that can be referred to such a form. The planes of the series r, referred to a common type for all the crystals, are all different in symbol on one crystal, from what they are on either of the others; and so with the other series. For example, in the series e, for figure I, the planes are $1 : \frac{5}{7}$, $1 : \frac{4}{7}$, $1 : \frac{3}{7}$, $1 : \frac{2}{7}$, $1 : \frac{1}{7}$; for figure II, $1 : \frac{3}{5}$, $1 : \frac{1}{5}$; for figure III, $1 : \frac{7}{5}$, $1 : \frac{5}{5}$, $1 : \frac{3}{5}$, $1 : \frac{1}{5}$. The planes here are not identical in any one instance, neither have they a simple relation. And again we observe that planes which have nearly the same inclination towards A, are still different planes.

But the approximation of the three forms under a common type is still possible, and in such a way that we believe it to be the only true method of viewing the relations of the crystals. We observe that the inclinations of A on i^2 in figures I and III, and on i in figure II, differ but little from one another. In figure I

this angle is 124° 16′; in figure II, 122° 27′; in figure III, 125° 14½′. The whole range of difference is only 2° 46′.* Taking these planes as homologous, the difference in the dimensions of the three types is small, not exceeding what in other species is known to be produced by small variations in composition dependent on isomorphous substitutions. Moreover, the symbols of the planes, on this plan, have greater simplicity, while affording, of course, the same angles as in Scacchi's method.

We may consider the fundamental octahedron as belonging to the *r* series (instead of the *n* series); and then taking i^2 in figures I and III and *i* in figure II, as the form $\frac{1}{2} : \overline{\alpha} : 1$ the axes for the three forms will be as follows:—

	a	*b*	*c*
Fig. I, ...	1·3588	1	0·4629
" II, ...	1·4536	1	0·4629
" III, ...	1·3115	1	0·4629

It will be observed that

a in figure I is *one third* of 4·0764 (*a* of type I.)
a " II is *one half* of 2·9090 (*a* of type II.)
a " III is *one fourth* of 5·2430 (*a* of type III.)

Also *c* in each, is *one half* of *c* in the types I, II, III, which is owing to our taking as the zone of the fundamental form, the *r* series instead of the *n* series,—the axes *c* in these series having the relation of 2 : 1.

From the above, the vertical axes in these forms is observed to vary nearly as 136 : 145 : 131, not a large variation. This ratio is equivalent to

14 : 15 : 13½,

which corresponds to the ratio 7 : 5 : 9 between Scacchi's vertical axes, as will be deduced by taking into view the ratio which subsists between *a* in each of the three types of M. Scacchi, and the *a* in our fundamental forms as above given.†

We have repeated the three figures of Humite, (see figs. A, B, C,) with a new lettering, the crystallographic symbols being

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* In Scacchi's method of viewing the crystals, these planes referred to the common type, have the following symbols:—i^2 in fig. I $= 1 : \alpha : \frac{3}{7}$; *i* in fig. II $= 1 : \alpha : \frac{2}{5}$; i^2 in fig. III, $= 1 : \alpha : \frac{1}{3}$. In the author's method, each has the symbol $\frac{1}{2} : \alpha : 1$ (equivalent to $1 : \alpha : 2$).

† This is shown as follows:—

Since 4·0764 : 2·9090 :: 7 : 5, and 4·0764 = 3 × 1·3588 and 2·9090 = 2 × 1·4536 nearly,

Therefore, 3 × 1·3588 : 2 × 1·4536 :: 7 : 5

∴ 1·3588 : 1·4536 :: 2 × 7 : 3 × 5 :: 14 : 15.

By the same process the other ratios are obtained.

used in the lettering, as explained in the last volume of this Journal.*

From the crystals, the symbols of the planes may be at once read off, and those of each series compared. There is a remarkable simplicity in the series;—and moreover, the parallelism between these related forms is well brought out; we appear therefore to be sustained in this mode of viewing these complex crystals.

We observe that—

The $m:1:\breve{\infty}$ series in fig. A, (*e* of Scacchi), has for *m* the values $\frac{3}{1}, \frac{3}{2}, \frac{3}{3}, \frac{3}{4}, \frac{3}{5}$

The " " in fig. B, " " $\frac{2}{1}, \frac{2}{3}, \frac{2}{5}$,†

The " " in fig. C, " " $\frac{4}{1}, \frac{4}{3}, \frac{4}{5}, \frac{4}{7}$

The $m:1:1$ " (*r* above) in fig. A, has for *m* the values $\frac{3}{2}, \frac{3}{4}, \frac{3}{6}, \frac{3}{8}, \frac{3}{10}$

The " " in fig. B, " " $\frac{2}{1}, \frac{2}{3}, \frac{2}{5}$

The " " in fig. C, " " $\frac{4}{1}, \frac{4}{3}, \frac{4}{5}, \frac{4}{7}, \frac{4}{9}, \frac{4}{11}, \frac{4}{13}$

The $m:\breve{\infty}:1$ series (*i* above) in fig. A, have for *m* the values $\frac{3}{2}, \frac{3}{6}, \frac{3}{10}$

The " " in fig. B, " " " $\frac{1}{2}$

The " " in fig. C, " " " $1, \frac{1}{3}, \frac{1}{5}$.

The values of *m* for the series $m:1:2$, (*n* above) and for $m:1:3$, (*m* above) will be read off from the figure.

In this method therefore, we have no sacrifice of accuracy in the angles, nor of simplicity in the exhibited relations of the planes; on the contrary, the crystals are more readily compared, and their actual differences more easily noted, than by Scacchi's method.

We gather at once, that the three crystals although approximately alike in their vertical axes, differ in the mathematical series expressing the positions of the secondary planes.

These series are—

For fig. B, $\frac{3}{1}, \frac{3}{2}, \frac{3}{3}, \frac{3}{4}, \frac{3}{5}$, or $\frac{3}{2}, \frac{3}{4}, \frac{3}{6}, \frac{3}{8}$, the latter not essentially differing from the former, as the two are alike in the alternate terms.

For fig. B, $\frac{2}{1}, \frac{2}{3}, \frac{2}{5}, \frac{2}{7}$.

For fig. C, $\frac{4}{1}, \frac{4}{3}, \frac{4}{5}, \frac{4}{7}, \frac{4}{9}, \frac{4}{11}, \frac{4}{13}$.

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* The writer has thought it preferable to use the letter I (or *i*), for ∞ (infinity) instead of O (or o), (as proposed in volume xiii, page 399), since the letter O is so readily confounded with 0 (zero). By way of explanation we give in this place Naumann's crystallographic symbols corresponding to some of those of figure A.

Fig. A,	$\frac{3}{6}$	$\frac{3}{4}$	$\frac{3}{2}$	I	$\frac{3}{10}\breve{i}$	$\frac{3}{8}\breve{i}$	$\frac{3}{2}\breve{i}$	$1\breve{2}$	$3\breve{2}$	$\frac{3}{2}\breve{i}$	$\frac{3}{1}\breve{i}$	$i\breve{3}$	$I\breve{I}$
Naum.,	$\frac{3}{6}$P	$\frac{3}{4}$P	$\frac{3}{2}$P	∞P	$\frac{3}{10}\breve{P}\infty$	$\frac{3}{6}P\breve{\infty}$	$\frac{3}{2}\breve{P}\infty$	$\breve{P}2$	$3\breve{P}2$	$\frac{3}{2}\breve{P}\infty$	$\frac{3}{1}\breve{P}\infty$	$\infty\breve{P}3$	$\infty\breve{P}\infty$

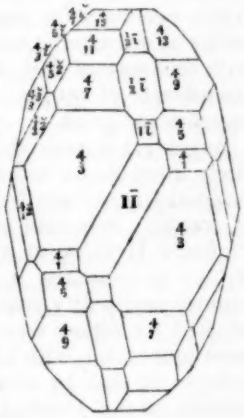
In writing the symbols, such as $1\breve{2}$, $3\breve{2}$, the writer proposes to put in a hyphen, thus, $1\text{-}\breve{2}$, $3\text{-}\breve{2}$; on the crystal this is rarely necessary.

In the above $\frac{3}{1}$ is written for 3, in order to make more obvious the relations of the numbers in the series.

† The plane of composition for twins of fig. II or B and not an observed plane.

These are each parts of distinct infinite series, and they indicate the character of the modification in the attracting power of the molecules by which the secondary planes are produced. They in fact, appear to contain the elements or data for deducing a general law at the basis of such modifications in the attraction, both for these and all crystals. The relations of the curves indicated by these different series may be deduced, and thereby we may have an expression for the particular modifications in the attraction of the molecule, through which the several types originated. In a former paper, on attraction in crystals,* the writer has shown that, supposing the attraction in the normal state to be such as will produce in the monometric system a cube, or in the trimetric, a rectangular prism, it must be true, whenever secondary planes are produced, that the ratio between the force of attraction and the length of the axes is different, and further, that the attraction is relatively diminished, inasmuch as the angles and edges are not filled out. In the curves, indicated by the above series, the differences as regards these modifications of the attraction, between the three forms above, are exhibited, and we may almost say, measured off. To follow out this subject the condition of the force in the normal molecule of given dimensions, as partly illustrated by magnetism, should necessarily be first worked out, and then the variations which are indicated by the series of planes. We simply throw out these suggestions at this time, hoping that mathematical knowledge of the requisite power may soon be brought to bear upon the laws for the occurrence of secondary planes.

M. Scacchi also points out a singular example of hemihedrism observed in crystals of the 2nd and 3d type, as well as some compound crystals of the same types. The annexed figure, which is of the 3d type, illustrates this point. The alternate planes which are wanting on one side, are present alone, out of the series, on the other. There is hence a spiral arrangement as in plagihedral quartz, and the spiral turn may be to the right or left.



The twin crystals are compounded parallel to the plane e^3 ($\frac{4}{3}\breve{i}$) in the third type, and in the second parallel to an e ($\frac{2}{3}\breve{i}$) which has not yet been observed in this type, having Scacchi's symbol $1 : 5 : \infty$. Of the former, stellate

* See this Journal, [2], iv, 373.

compound forms of 6 crystals, plagihedral in character, have been observed, and a figure is given in the paper.

The Humite occurs mostly either in foliated or granular limestone, or in a peculiar kind of granitic rock along with white olivine, mica and magnetite. In the former of these rocks the crystals are of the 2d or 3d type, and in the latter of the 1st or 3d. The color for each type varies between brown, reddish brown, yellow and white. G.=3·2; of a white crystal of the 1st type 3·234; a brown of the 3d, 3·199; a yellowish of the 3d, 3·186; a yellow of the 2d, 3·177. H.=6 – 6·5. The mineral is easily soluble with muriatic acid when pulverized. The identity of Humite with Chondrodite in chemical constitution was shown by Prof. C. Marignac, who also investigated with much labor the crystallography of the species, and distinguished three types among the crystals. He failed however of detecting their true relations, owing to his making e^2 of figs. I and II homologous planes, and r^4 of fig. I identical with r^6 of fig. III.

ART. XXI.—*Further Remarks on Ventilation and the Warming of Rooms;* by S. WEBBER, M.D., Charlestown, N. H.

IN a former number of this Journal, in some strictures on an article by Prof. Hosking,† a tolerably full elementary statement was given of some of the leading principles of ventilation in connection with the warming of rooms by means of artificial heat. It is now proposed to carry on the subject by a few additional remarks necessary for setting forth fairly the merits of different modes of warming in connection with preserving purity of the air, with economy of fuel, and also of preserving purity of the air in assemblages of people, where warmth is not required, or when it becomes too great.

Supposing a room to be so tight by means of well and accurately fitted doors and windows, that no noticeable quantity of external air can enter by crevices, probably the most pleasant way of warming it in cold weather will be nearly that mentioned by Professor Hosking as a plan of recent origin, though from the writers recollections it was shown to have been used in this country nearly fifty years ago. This is, to have an open fire-place, adapted for either wood or coal, as either kind of fuel may be most convenient, with a hollow hearth, sides and back, into which hollows air shall be admitted by a pipe leading from the open air outside of the building, and which, when warmed by contact with the heated sides of the fire-place, in contact or nearly so with the fire, shall pass out into the room by openings in front of

† Volume xiii, page 374.

the jambs, which openings may be more or less, or wholly closed at pleasure, by some contrivance like a sliding lid or valve. In this case the air for the support of the fire will be furnished from the lower part of the room, and consists of the coldest part of the air in the room, and that most contaminated with carbonic acid gas. This by the constant ascent of the warm air from the supply openings to the upper part of the room, will be constantly and equably pressed towards the only mode of escape for it, the opening of the fire-place into the chimney above, and it will at the same time be drawn thither by the suction occasioned by the rarefaction and ascent of the air in the chimney from the action of the fire. The air of the room will thus be perpetually renewed, and the renewal will be made with warm pure airs. Unless the room be over crowded, over lighted, or over heated, no other ventilator will be wanted for preserving such a degree of purity of the air, as is necessary for comfort and health.

Some little attention however is requisite to the material of the fire-place. If it be made of iron, as has been sometimes the case, when the fire is strong, the iron, if in immediate contact with it, becomes greatly heated, perhaps red-hot, and in this condition will readily decompose some of the air coming in contact with it, depriving it of its oxygen, and sending into the room not pure warm air, but air unduly charged with nitrogen. Some other substance, which when heated, will not thus act upon the air, seems preferable. Iron will do well enough for the bottom or hearth, if a bed of ashes be permitted customarily to cover it, sufficient to prevent its becoming unduly heated. The sides and back may be built in the common way of brick, the only objection being, that this material is a slow conductor of heat, and considerable time must elapse after the kindling of the fire, before any perceptible effect can be noticed on the air contained in the hollows. Brick moreover, in houses of the better class, will hardly be considered handsome enough. A fire-place constructed of slabs of soapstone will be better in both of these points, though it is by no means so good a conductor of heat as iron, while it is a better one than brick. It may however be observed that by way of compensation, though the air in the hollows will not be warmed so quickly by these two substances, yet that it will continue to be warmed longer after the fire has gone out; as they seem to have a much greater capacity for caloric than iron, and under equal circumstances will continue to impart it long after iron has become cold.

The porcelain of which stoves are frequently constructed in France and Germany, might probably be applied with advantage to the construction of fire-places of this kind, if it could be readily obtained, where soapstone was not easily to be had. For the greater economy of fuel the upper part of the back of the fire-place should be brought forward, so as to leave the throat of the

chimney as narrow as possible consistently with a fair and free escape of the smoke; and it might be provided with a slide under the mantle bar, for the purpose of rendering the opening wider or narrower, as the state of the fire and the chimney may require.

Another point to be carefully attended to is the character of the air brought in by the supply pipe to be warmed and passed into the room. This should be brought from the outside of the house, in some place where it may be presumed to have at least a fair average degree of purity, where the currents of the atmosphere have a free circulation, and, if possible, where sunshine penetrates during some portion of the day. To bring it from under the house merely, or from a cellar, from the neighborhood of a drain, or from a damp close, where wind and sunshine seldom or never penetrate, is only to change one poison for another.

But this mode of warming and ventilating rooms when artificial warmth is required, however excellent in some respects, is yet deficient in one great point, economy. However carefully a chimney and fire-place may be constructed, with an open fire whether of wood burning on the hearth or of coal burning in a grate, there must unavoidably be a great waste of caloric, as a large portion of it passes directly from the fire into the chimney, and out into the atmosphere, heating the chimney as it passes up, and thus increasing the strength of the draft by which it is raised. Hence a much greater consumption of fuel is necessary for giving the requisite warmth to a room, and moreover, as the bulk of the caloric that is sent into the room is thrown into it by radiation from one side or end, it is difficult to warm the room so equably, that a near approach to the fire shall not be very uncomfortable from heat, when the remote parts of it are not so from cold, whenever the temperature of the atmosphere abroad is very low.

Where not one or two rooms merely, but a considerable portion of a house, passages and all, are to be warmed,—as modern ideas of comfort in many cases require,—the expense of fuel in our long and severe winters becomes a matter of considerable importance to those not abounding in wealth; as also does the care necessary for attending to so many fires. Hence has arisen the plan of having one large general fire in the basement or cellar, this fire placed in a furnace arranged for heating a constantly renewed supply of fresh air, which is then distributed by pipes to the different rooms and passages which it is wished to warm. If this plan be carried into effect in an otherwise unexceptionable manner, it is probable, that though the first outlay be considerable, yet that as regards the regular consumption of fuel for obtaining a given degree of warmth in the house, and also as to the amount of labor necessary, there may be much sound economy in the plan. But that the arrangements generally made are

unexceptionable, or even not in a considerable degree otherwise, is very doubtful to say the least. As generally constructed, the part of the furnace containing the fire and through which the caloric passes to be communicated to the air admitted between the inner and outer walls, is made of iron, and as the fire within is large and often fierce, it must, when much warmth is required, be often very intensely heated, so as not only to decompose the air, as before stated, but even the watery vapor contained in it, and thus throw into the rooms not only air with an undue portion of nitrogen, but unduly dry, and still more unfit for breathing from being contaminated with hydrogen. Furthermore, when there is, as is almost always the case, any fine organic dust floating in the atmosphere, such of this as comes in contact with the iron, if that should be at a red heat, will in part at least be burned, and the product of its combustion go still farther to pollute the air. The volume of gaseous matter that may be produced by the burning of a very minute quantity of organic dust, is vastly more considerable than those not familiar with the subject will readily believe. In short, all the cautions given under the head of hollow air-heating fire-places must be observed with greatly increased strictness in the management of furnaces for warming houses. The amount of precaution required increases with the size and intensity of the fire that is used. For regulating the purity of the air in rooms thus warmed, while still the full supply of warmth is desired, there should be, near the level of the floor, a good sized ventilating aperture, communicating with the flue of a chimney, or with an up-draught pipe.

Open stoves, as they are called, are but modifications of fire-places more or less detached from the chimney. They provide well for one part of the necessary ventilation, the means of discharging the impure air through the draft into the chimney, but they are usually entirely deficient in the other essential part, the means of warming and throwing into the room a supply of fresh air to take the place of that which thus passes out. For this the room has to depend upon the indraught of cold air through the crevices of doors and windows, and if these be well closed, such stoves smoke intolerably, and the air of the room soon becomes otherwise very impure. This may be obviated by making such stoves double, and admitting the air into the hollow under the hearth by a pipe leading from the external air beneath the floor. This air, well warmed by passing through the hollows of the back and sides, may be permitted to pass through a register in the upper plate of the top. The same remarks as to the materials and degree of heat, which were given under the head of fire-places, are appropriate to these open stoves. They are decidedly more economical than fire-places in the base of the chimney, when they are completely detached from the walls of an

apartment, since all the caloric communicated by the inclosed air to the outer plates of the stove is radiated by them into the room, forming no inconsiderable addition to its warmth.

Still this kind of stove requires a large, free, and pretty direct passage for carrying off the smoke of the fire; and this also permits the escape of a large portion of the caloric produced by it, so that they are decidedly less economical than close stoves, where only a small opening is left for the indraught of the air from the room to the fire, to maintain its active combustion: through which small opening the current is so strong, that a much less sized smoke pipe is required, and this may be much more tortuous in its approach to the chimney flue, thus carrying from the stove less of the caloric, and permitting a considerable part of what it does receive, to escape by radiation from its sides. If a comparatively large stove of this kind be used, with a good length of funnel, making, if possible, several turns up and down before finally entering the chimney or passing into the air, as great an economy of fuel will be obtained as is probably desirable; for some amount of caloric must pass into the chimney, both that this may perform its office well, and for its preservation. As commonly used the two great defects of this kind of stove are, that the aperture for the supply of air to the fire is hardly large enough to carry off the foul air from a room, if occupied by several persons, and if two or three lights are burning in it; and that no provision is made for the renovation of the air by introducing warm fresh air. The first of these is easily remedied by a ventilating aperture on a low level communicating with the chimney flue, to be used more or less as occasion may require; the second may be corrected by making the stove double in the same way as was mentioned for open stoves. Stoves of this kind, made of soapstone or porcelain, are preferable to those made of iron; but if the latter be large and but moderately heated, no essential evil will arise from the material. When the polish with which it is customary to coat iron stoves, readily gets brown or ash colored, it is evidence that the stove is far too highly heated. Double close stoves made of soapstone have lately come into partial use, and their performance is in all respects very unexceptionable.

Air-tight stoves are excellent as to economy of fuel, but this is their only merit. They impart warmth in the highest possible degree, but in themselves do nothing for a change of air, neither carrying off any noticeable quantity of foul air, nor supplying any fresh warm air. These defects are the same with those of close stoves but in the highest degree, and they may be remedied in the same way; the ventilating opening into the chimney should however be larger than in a common close stove. The very perfection however with which they impart their caloric to the room, is a seri-

ous defect, for if a chimney is used only with one or more of these stoves, there is not sufficient warmth imparted to it in very cold weather, to prevent the pyroligneous acid generated in the combustion of the fuel, and passing in vapor by the edges of the *damper*, from being condensed against the inside of the chimney, where it penetrates the mortar with which the bricks are laid, and acting upon the lime destroys the tenacity of the cement and passes through it into the rooms. An instance of this kind fell under the writer's observation. The chimney in this case had two flues, one from the ground floor, and one from the chamber above. Both were provided with air-tight stoves, which were managed with rigor according to the directions of the inventor. In the course of the first winter the pyroligneous acid began to show itself in the chamber, oozing through the plastering, on the sides of the chimney where it was laid upon the bricks, and running in streams down to the floor. The same thing took place even more copiously in the loft above the chamber, and the fluid that ran down there, spread in puddles over the ceiling of the chamber which intercepted it, and before spring made its way through the plaster of this ceiling in large patches, dripping copiously in various places, defacing and spoiling the carpets and furniture below, and rendering it necessary to set a number of vessels on the floor to catch the dropping fluid, and prevent it from effecting the same destruction in the parlor below, which indeed, with all precautions that were taken, did not entirely escape. The chamber was rendered uninhabitable, and all that part of the house was troubled with "a most ancient and fish-like smell." The use of the stoves as *air-tights* had to be entirely given up; and it was found necessary to rebuild the chimney and new plaster the ceiling of the rooms. At the suggestion of the writer the chimney was built double, a space of two inches being left between the inner and outer walls, occasional bricks passing through this as binders, and the hollows being closed over at the top. The warm and impure air passed into these hollows through the ventilating opening of the rooms and issued into the internal flue by lateral openings near the top. Advice at the same time was given, to let the heat pass freely into the chimney occasionally so as to keep the bricks of the internal wall sufficiently warm to prevent the condensation of the pyroligneous vapor. These precautions for two or three years were found effectual. After that time a furnace was used.

The use of steam-pipes as a means of warming dwelling-houses has been attempted, but has found so little favor, that it is hardly worth while to say any thing about them. They are costly and troublesome, and have in themselves no means of changing the air. In establishments where steam is generated in large quantities for other purposes, it may be profitable to employ waste or

spare steam for the purpose of warming such portions of the building as it can readily be conveyed to without much expense, the necessary purification of the air being otherwise provided for.

Such are the principal modes that have been employed for impartin gwarmth to dwelling-houses, with their advantages and disadvantages, both as to warming, and as to preserving the purity of the air while diffusing heat, with the means necessary for so doing while the increase or maintenance of warmth is desirable. But this warmth so artificially procured, may become excessive. From too large a fire, the presence of too many persons in a room where the fire is, and the burning of numerous lights, the air may become too warm and impure, and additional ventilation and with cooler air may be required. In this case a ventilating aperture in the upper part of the chimney is wanted, to permit the escape of the warm air from the upper part of the room and with it such of the gaseous exhalations, engendered in such cases, as are of a light specific gravity. Rooms therefore used for the reception of company where any considerable number of persons are likely to be occasionally assembled, should always be provided with a high ventilator. It may not be always convenient to put out the fire, or materially to lesson the number of lights, though the ingress of warm air from the supply pipes may be stopped, and that already in may be suffered to escape through the upper ventilator. That it may do this however, other air must be admitted. Opening doors and windows, one or more as the need may be, will readily do this; but unpleasant and excessive draughts are thus created, oftentimes more immediately prejudicial to health to those fully exposed to them, than a slower cooling and purification of the air by means of the upper ventilation only. A proper ventilating opening or openings, for the admission of fresh cool air will be required. These should not be on the floor, as the cool air would thus be thrown principally about the feet and ancles, where least needed and most prejudicial, and whence it would ascend slowly to the level of the mouth and nostrils, much warmed in its ascent, and much loaded with emanations from the body. It should be admitted at a high level near the ceiling, at some distance from the upper warm-air ventilator, and if possible on the opposite side of the room, so as to diffuse itself to some distance in that higher portion, driving the warm air before it to its appropriate place of escape, and descending as it moves forward, mixing with, condensing, and quickly bearing down with it to the lower part of the room, the impurities it might meet with, conveying grateful refreshment to the lungs, and checking the ascent of impurities from below the mouth and nostrils. The very coolness applied to the head is one of the best means of preventing the bad effects of the inhalation of air impure from an undue mixture of carbonic acid,

as this part of the system is the first almost to manifest the effects of blood not duly purified in the lungs.

The common mode of admitting air into too warm a room by letting down the upper sash of a window, where it can be done, in preference to raising the lower, is founded upon this principle, and is perfectly correct. The mode however is somewhat defective, as the air is admitted in too large a body and with too strong a current, except for excessive cases, and by producing too sudden a check to perspiration and to the secretions of the mucous membranes of the air-passages, is apt to produce inflammatory affections of the head and throat. Were it to pass through a sheet of wire gauze or perforated plate of thin metal, its force and intensity would be much lessened, as it would be divided into numerous minute currents, and instead of descending like a cataract, would fall quietly like spray or mist, mixing intimately with the warm air and gently cooling it, and refreshing and cooling without chilling, the heads, necks and air-passages of the persons in the room. Were a space of a foot in depth in the upper part of one or two windows with a moveable upper sash thus provided, (and this might easily be done, and so as even to be ornamental,) no better ventilators for supplying cool fresh air to an over-heated room need be wished for.

This ventilator with the internal one into the upper part of the chimney will be found very serviceable at times when a fire is not needed, and also when from the number of persons and lights a room becomes too warm, while the weather is still so cool that the external air cannot be admitted freely by open windows. Indeed it seems as if, in a room provided with these different ventilators and the means of warming recommended, there would be no great difficulty to be encountered in keeping the desirable degree of warmth and purity of the air in any but hot and sultry weather, when of course the temperature of the external air must in some degree limit the amount of coolness to be obtained by ventilation.

It was mentioned in the former part of these remarks in connection with the subject of keeping a vessel of water upon a stove in order to supply the air with what was considered a proper degree of moisture, that the air heated by a stove was not the more dry for heating, but only had its capacity for dissolving vapor increased, by which means it absorbed the moisture from all things in the room containing it, rendering *them* indeed more dry, but becoming more moist itself. This undoubtedly has a bad effect upon furniture not thoroughly seasoned and dried in the making, causing it to shrink, crack, and warp; and even furniture made in a moist or cool season of the year, though of apparently well seasoned wood, will under the influence of a steadily warmed room, where the heat is kept up to summer tempera-

ture, say 76° of Fahrenheit, shew often manifest signs of undue dryness. The effects upon the human system, especially in a person unaccustomed to it, are an unusual dryness of the air-passages of the mouth and throat, creating a disposition to thirst, and requiring a larger supply of fluid in the way of drink, than is customary in the cold season of the year, while if, as is commonly the case in this season even in the house, the dress is materially thicker than in summer, a corresponding increase of the perspiration from the surface of the body is also produced, and this elimination of fluid from the skin, though it renders it more moist, diminishes rapidly the quantity in the system, and coöperates with the increase of evaporation from the lining of the air-passages, in creating the demand for a larger supply of drink. In this however there is no especial harm, as it is only what happens naturally in the warm season of the year, and if the desire be moderately and reasonably gratified with appropriate liquid, the adjustment of the system will take care of itself. This amount of heat, 76°, is however rather excessive for persons in health warmly clothed, and who are frequently passing out into the cold external air, as the pores of the skin are too much opened by it, and they run the risk of taking cold by a sudden check of the perspiration in the parts of the surface most exposed to the chill of the atmosphere.

Now the effect of throwing into air already warm and unduly moist, a large additional supply of warm vapor, as is the case when water is suffered to evaporate from the top of a stove, is to produce a relaxing effect upon all the surfaces of the body exposed to its influence, both the mucous membranes and the skin, and thereby to render one more liable to feel the ill effects of a check from coming in contact with the cold external air. If any thing in the way of an extra supply of moisture were advisable or admissible, it would be simply to place a vase or two of water in different parts of the room, and let the air drink from it gradually and at its own temperature, a sufficient supply of moisture to satisfy its capacity. It would thus be naturally saturated, and no more; and the furniture at least would escape injury, and possibly, perhaps probably, the human form would receive no detriment, if the warmth of the room was limited to about 62°–65°, which will be quite sufficient for comfort for healthy persons fairly clad for the cool or cold season. In the case of invalids some departure from these limits both of warmth and moisture, may be advisable according to circumstances, but these should be regulated by the advice of the medical attendant, to suit the requisitions of each case.

ART. XXII.—*Notes on the Use of the Zenith Telescope in Determining Latitudes in the Coast Survey, by Talcott's Method, and on the Reduction of the Observations;* by A. D. BACHE, Superintendent U. S. Coast Survey.*

THE method of determining latitudes, by measuring differences of meridian zenith distance of two stars, of nearly the same distance from, and on opposite sides of, the zenith, employed by Capt. Andrew Talcott, late of the U. S. Corps of Engineers, appears to me one of the most valuable improvements in practical astronomy of recent years. It has been described, with care, by Professor Courtenay, in the Journal of the Franklin Institute; by Major Emory, in his report of observations in connection with the northeastern boundary of the United States; and by Capt. Lee, of the U. S. Topographical Engineers, by whom it was repeatedly used in the operations of the Coast Survey.

The chief modifications in the instrument, since its introduction in the Survey, have been—in securing stability, by a brass arc, instead of a sliding rod, (proposed by Major Emory and by me;) in increasing the facility of reaching the zenith, by raising the central columns, and somewhat diminishing the diameter of the azimuth circle; in substituting a single for a double micrometer; in providing a parallactic eye-piece; in illuminating by a lamp, not resting on the instrument; in bringing the divisions of the level and micrometer into just relations; in an adjustment for the verticality of the axis, (adapted by Mr. Simms, of London;) and in providing stops to set the instrument in azimuth.

Quite a new form was proposed for the instrument, by the late R. H. Fauntleroy, one of the Assistants of the Coast Survey, in which the telescope was to be used for determining time; which it is capable of doing with sufficient precision for observations of latitude. The instruments of this kind used upon the Coast Survey, have been, generally, made by William Simms, of London; one has, however, been recently constructed by Mr. Würdemann, of Washington,† and another is in progress of making, under Mr. Saxton's direction.

As used by us, the observations are made when each star is very nearly in the meridian, and as nearly as possible when passing the center of the field of the telescope. When there is a recorder to assist the observer, he calls out the setting of the instrument for each pair of stars, and when the star should enter the field; thenceforward calls each ten seconds, the observer follow-

* From the Proceedings of the American Association for the Advancement of Science, vol. v, (5th Meeting, at Cincinnati,) p. 151.

† In this instrument the circular or "windmill" clamp has been applied for keeping the instrument in position, and with great advantage.

ing the star with the horizontal wire, and moving the instrument in azimuth, if it appears necessary, as the time of culmination approaches, to bring the star in the middle of the field. When within ten seconds, the recorder calls each second, and the instant of the previously computed culmination, when, the wire being upon the star, the first part of the observation is complete. The level and micrometer are read and recorded. The same process is repeated after the instrument has been turned 180° to observe the opposite star of the pair, on the other side of the zenith. A single observation on the meridian has, in our experience, been found preferable to several circum-meridian observations.

NUMBER I.

Form for recording Observations for Latitudes with Z. Telescope, Mt. Independence, (Black Strap,) Maine, Sept. 25, 1849.

STAR.	N. or S.	MICROMETER. Turns.	Divis.	LEVEL. N.	S.	Time of observation by Chronom.	Time of culmination by Chronom.	MERIDIAN DISTANCE.	Coef red.	REDUCTION TO MERIDIAN.	REMARKS.
						H. M. S.	H. M. S.				Sid. chron. 17h at 20h. 14m. 28·91s.
6851	S.	14	97·0	37 0	47·0	19 50 13	19 50 13				Slow 00h. 00m. 28s. 06.
6928	N.	7	27·5	49 0	35·0	20 01 49	20 01 48				Hourly rate gaining, 00·09s.
6893	N.	8	3·0	47·0	38·0	20 10 23	20 10 22				Commencement of obser.: Barometer 29·22; interior thermometer 63·3; exterior thermometer 62·7.
6986	S.	6	91·3	38 0	47·0	20 12 21	20 12 20				
7008	S.	14	10 0	46·5	38·5	20 14 21	20 14 21				*Taken off the meridian.
7076	N.	1	74·5	39 0	46·2	20 23 26	20 23 25				Lat. = 43° 45′ 30″ cos = 9·85570
								H. M. S.			N. P. D. 47° 15′ 32″ sin = 9·86594
8076	S.	11	60·0	50 0	35·5	23 03 15	23 03 05	00 00 10	0·005	− 1″·49	Z. D. = 1° 01′ 02″ ar. co. sin. 1·75963
8115	N.	2	98·5	37·5	48·0	23 10 27	23 10 27				X = 29·9 = 1·47927

The form of record is not essentially different from that used by Captain Talcott, and by subsequent observers. By recording the

readings of the level as N. and S. ends, instead of object and eye-ends, some trouble is saved. The table, with its headings, is as above.

Of the arrangement of the instrument in its place, and the simple adjustments it requires, when not employed to obtain time, it is not necessary to speak. We mount it, usually, on a block of stone, or wood, sunk about two feet in the ground, and find little advantage in one material over the other.

The instrument being in place, the first point is, to determine the value of the micrometer in angular measure. Several methods have been used for this purpose: the most common is, by turning the micrometer at right angles to the position in which it is generally used, and noting the number of divisions passed over by Polaris, or some other circumpolar star, in a given time, when near its culmination. Another method, introduced by Assistant C. O. Boutelle, is, to observe Polaris near elongation, when rapidly rising or falling, with but a slight motion in azimuth. This is a pretty method, and avoids the displacement of the micrometer. When a theodolite is at hand, we generally obtain the micrometer values by the apparent diameter of a distant object, as measured in angular and in micrometer divisions, by the two instruments.

A ring of lead is placed around the sliding tube at the eye-end of the telescope, to prevent a change of focus. It is usual to test the different parts of the screw in obtaining these values, turning the micrometer both forward and backward. A record of a series of observations of the last named kind is given, below, with their discussion:

NUMBER II.

Values of Micrometer Divisions, No. 1, by Distant Mark.

Date.	Distance from	With Micrometer.	With Theodolite.	Mic. value of one division	$a \smile x$	$(a \smile x)^2$
		divis.	″	″		
May 16,	o to S	1213·0=	463·1	·3818	·0004	·00000016
	o " W	1324·0	503·2	·3800	14	0196
	o " A	2845·0	1096	·3152	38	1444
	Sums					

e=o″·0051= probable error of a single observation.

E=o ·0012= " " mean of all.

Mean value of one division of micrometer =o″·3805±o″·0012

From these observations, a table is made, which, by simple inspection, shows the angular value of any number of turns of the screw, and parts of a turn. By suitably selecting the pairs of stars, any effect of inaccuracy in this determination may be avoided, by making the sum of the zenith distances, of all the pairs N. and S. of the zenith, zero. It is, generally, convenient to approach nearly to the fulfillment of this condition.

The value of the divisions of the level is next found in terms of the micrometer value; passing the bubble from one end to the other of the level, so as to detect and measure any irregularities. The telescope is pointed at a distant mark, or a collimating telescope is used; the displacement of the line of collimation, as the bubble of the level is made to travel from one end of the tube to the other, being measured by the micrometer. The advantage of the collimator, from the stillness of the air through which the observation is made, is shown in the following comparative results, by the two methods:

NUMBER III.

Value of Level Divisions, No. 1, by Distant Mark.

SERIES.	Level.		Micrometer.		Differ.	Differ.	Value of one division of level in
	O	E	Turns.	Divis.	Level.	Micr.	micr. divisions.
	64·5	14·7	0	0	4·25	19	4·47
	60·3	19·0	0	19	4·40	20	4·54
	56·0	23·5	0	39	5·50	21	3·82
	50·5	29·0	0	60			
	$e = 0{\cdot}5862$ in micr. divisions.						
	$E = 0{\cdot}03275$ " "						
	Mean value of one division level $= 1''{\cdot}5193$						
	No. 2 by collimator.						
	$e = 0{\cdot}0770$						
	$E = 0{\cdot}0181$						

The value of the level divisions is then converted into arc, and a table prepared, which, by inspection, shows the correction to twice the latitude for an excess of sum of readings of north ends over sum of south ends, or *vice versa;* applying this correction in north latitude, with the sign N.−S. I constructed a table, from which the correction for level could be taken by inspection; the sum of the north end readings being arranged at the top, and the sum of the south end at the side—the correction being found on a diagonal line. It has not, however, found favor with the observers: but they usually prefer a table of single entry, in which the argument is the difference of the series of north and south end readings, and opposite the correction in arc.

There are two corrections, which it may be as well to notice in this place; viz., for reduction to the meridian and refraction.

If the line of collimation of the telescope is off the meridian, the reduction to the meridian employed in altitude and azimuth instruments, and in sextant observations, applies. If the axis, or vertical wire, is in the meridian, and the star is observed before or after culmination, then the correction is such as is used with the zenith sector and with the meridian circle, viz.: $x = -\frac{H^2}{4}$.

Sin 2Δ, in which x is the correction, H the hour angle, and Δ the polar distance of the star.

These corrections were formerly tabulated, but now are generally avoided by the mode of observing, and the cases in which they occur are computed separately. In general, the tendency is to avoid methods which introduce tedious calculations, unless attended with decided advantage.

One of the great advantages of Talcott's method is, that the correction for refraction is very small; being for the difference, merely, of the two refractions on each side of the zenith. The correction for temperature and pressure of the air is, usually, insignificant; amounting, at the distance of 25° from the zenith, and for a difference of 20 minutes of zenith distance, two inches of the barometer, and 50° of the thermometer, (Fahr.), to only 0″·02. The whole correction for refraction is obtained by the following easy method, first used, I believe, by Prof. Gibbes, of Charleston: The refraction being nearly proportional to the tangent of the zenith distance, the differences for the two stars of the pair will be nearly the differential of the tangent of the zenith distance of the star south of the zenith, and will be inversely proportional to the square of the cosine.

Call Zs the true zenith distance of the star south of the zenith, and Zn the same for the star north of the zenith.

Then in each case the true zenith distance = the observed distance + the refraction, which is proportional to the tangent of the zenith distance;—or calling Zs_0 and Zn_0 the observed zenith distances of the star S and N of the zenith,

$$Zs = Zs_0 + m \tan Zs, \quad \text{and} \quad Zn = Zn_0 + m \tan Zn$$
$$Zs - Zn = Zs_0 - Zn_0 + m\,(\tan Zs - \tan Zn).$$

Since $\tan Zs - \tan Zn = \tan (Zs - Zn)\,(1 + \tan Zs \tan Zn)$ a table may easily be rigorously computed, or approximately,

$$d \tan Zs = \frac{d Zs}{\cos^2 Zs}$$

And the log correction is $\text{Log} \dfrac{m \sin 1'' \text{ diff. zen. dist.}}{\cos^2 Zs}$, from which a table is easily constructed.

The following table for correction for refraction to the nearest hundredth of a second, for different zenith distances and differences of zenith distance, has been computed by this method, by sub-assistant G. W. Dean, of the U. S. Coast Survey:

[B.]

Corrections for Refraction, to be used in correcting observations with Z. Telescope.

Micrometer arc.	ZENITH DISTANCES.										
	0° 30′	4° 10′	9° 40′	13° 00′	15° 40′	17° 50′	19° 40′	21° 20′	22° 50′	24° 10′	25° 25′
0′ 0″	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00
30	·01	·01	·01	·01	·01	·01	·01	·01	·01	·01	·01
1	·02	·02	·02	·02	·02	·02	·02	·02	·02	·02	·02
30	·02	·02	·03	·03	·03	·03	·03	·03	·03	·03	·03
2	·03	·03	·03	·04	·04	·04	·04	·04	·04	·04	·04
30	·04	·04	·04	·04	·05	·05	·05	·05	·05	·05	·05
3	·05	·05	·05	·05	·05	·06	·06	·06	·06	·06	·06
30	·06	·06	·06	·06	·06	·06	·07	·07	·07	·07	·07
4	·07	·07	·07	·07	·07	·07	·08	·08	·08	·08	·08
30	·08	·08	·08	·08	·08	·08	·09	·09	·09	·09	·09
5	·08	·08	·09	·09	·09	·09	·10	·10	·10	·10	·10
30	·09	·09	·10	·10	·10	·10	·10	·11	·11	·11	·11
6	·10	·10	·10	·11	·11	·11	·11	·12	·12	·12	·12
30	·11	·11	·11	·12	·12	·12	·12	·13	·13	·13	·13
7	·12	·12	·12	·12	·13	·13	·13	·14	·14	·14	·15
30	·13	·13	·13	·13	·14	·14	·14	·15	·15	·15	·16
8	·14	·14	·14	·14	·15	·15	·15	·16	·16	·16	·17
30	·14	·14	·15	·15	·16	·16	·16	·17	·17	·17	·18
9	·15	·15	·16	·16	·16	·17	·17	·18	·18	·18	·19
30	·16	·16	·17	·17	·17	·18	·18	·19	·19	·19	·20
10	·17	·17	·17	·18	·18	·19	·19	·20	·20	·20	·21
30	·18	·18	·18	·19	·19	·20	·20	·21	·21	·21	·22
11	·19	·19	·19	·20	·20	·20	·21	·21	·22	·22	·23
30	·19	·20	·20	·21	·21	·21	·22	·22	·23	·23	·24
12	·20	·20	·21	·21	·22	·22	·23	·23	·24	·24	·25
30	·21	·21	·22	·22	·23	·23	·24	·24	·25	·25	·26
13	·22	·22	·23	·23	·24	·24	·25	·25	·26	·26	·27
30	·23	·23	·24	·24	·25	·25	·26	·26	·27	·27	·28
14	·24	·24	·24	·25	·26	·26	·27	·27	·28	·29	·29
30	·25	·25	·25	·26	·27	·27	·28	·28	·29	·30	·30
15	·25	·26	·26	·27	·27	·28	·29	·29	·30	·31	·31
30	·26	·26	·27	·28	·28	·29	·30	·30	·31	·32	·32
16	·27	·27	·28	·29	·29	·30	·31	·31	·32	·33	·33
30	·28	·28	·29	·30	·30	·31	·32	32	·33	·34	·34
17	·29	·29	·30	·30	·31	·32	·33	·33	·34	·35	·35
30	·30	·30	·31	·31	·32	·33	·33	·34	·35	·36	·36
18	·31	·31	·31	·32	·33	·34	·34	·35	·36	·37	·37
30	·31	·32	·32	·33	·34	·35	·35	·36	·37	·38	·38
19	·32	·32	·33	·34	·35	·36	·36	·37	·38	·39	·40
30	·33	·33	·34	·35	·36	·36	·37	·38	·39	·40	·41
20	·34	·34	·35	·36	·37	·37	·38	·39	·40	·41	·42
30	·35	·35	·36	·37	·38	·38	·39	·40	·41	·42	·43
21	·36	·36	·37	·38	·38	·39	·40	·41	·42	·43	·44
30	·36	·37	·38	·38	·39	·40	·41	·42	·43	·44	·45
22	·37	·38	·38	·39	·40	·41	·42	·43	·44	·45	·46
30	·38	·38	·39	·40	·41	·42	·43	·44	·45	·46	·47
23	·39	·39	·40	·41	·42	·43	·44	·45	·46	·47	·48
30	·40	·40	·41	·42	·43	·44	·45	·46	·47	·48	·49
24	·41	·41	·42	·43	·44	·45	·46	·47	·48	·49	·50

The same table may be formed as conveniently by differences from the usual refraction tables.

In selecting the pair of stars for use with this instrument, we have found the following rules convenient or necessary to be observed. The British Association Catalogue has afforded ready means for their selection, and the computation of their places.

1. The latitude of the place is assumed to the nearest two or three minutes of arc.

2. The zenith distances should be as small as practicable (the instruments now used admit of ready access to the zenith in observations), and should not be extended beyond twenty-five degrees.

3. The differences of zenith distance should be small, and in no case exceed a convenient range of the micrometer, say, ten minutes of arc, corresponding (in the instruments which we use) to about thirteen turns of the micrometer.

4. The interval of time between the culmination of the stars of a pair should not be less than one minute; so as to give time deliberately to read the micrometer, and to turn the instrument in azimuth, to be prepared for observation; and should not exceed about twenty minutes, to avoid changes in the instruments.

5. The interval between the pairs should afford time for reading the micrometer and level, and for setting the instruments for the next pair. This will vary with different observers; but three minutes is about the time adopted by most of our observers. When the intervals between pairs are unavoidably long, they are filled up by observing transits for time.

6. The VI½ magnitude is the least that admits of easy observation, with the telescopes which we use. They are by Simms of London, have a focal length of forty inches, and object-glasses about three inches in diameter; and we commonly observe with a magnifying power of fifty or sixty.

7. In selecting pairs, all stars marked "doubtful" are rejected; in general, those having but one authority are not taken.

8. In order to be certain to embrace all desirable combinations, the catalogue is to be consulted from the earliest AR which the daylight, at the time of beginning the series of observations, permits, to the latest hour at which it is desirable to observe. Within this period of AR, the stars are divided into belts by their declinations; the breadth of each being equal to that of the field of the instrument, and being paired accordingly, the corresponding declinations north and south of the zenith, as in the following table for Mount Independence, near Portland, Maine; assumed latitude, 43° 45′, and field of the telescope 15′:

TABLE No. I.

For Selection of Pairs for Observation with Zenith Telescope.

No. of Star in B. A. C.	N. or S.	Mag.	Auth.	A. R.	N. P. D.
				h. *m.* *s.*	46° 00′ and 46° 30′
5997	S	VI	1	17 36 05	46° 27′ 14″
6095	"	"	1	17 53 25	46° 34′ 04″
6162	"	"	1	18 02 57	46° 33′ 16″
6720	"	"	1	19 29 59	46° 29′ 56″
7241	"	VI½	3	20 44 45	46° 30′ 14″
7681	N	VI	1	21 56 53	46° 04′ 18″

(15′ each side of zenith.)

No. of Star in B. A. C.	N. or S.	Mag.	Auth.	A. R.			N. P. D.
				h.	m.	s.	45° 45′ and 46° 45′
6013	N	VI	1	17	38	39	45° 50′ 53″
6728	S	V½	1	19	31	46	46° 37′ 40″
6731	N	VI	1	19	31	59	45° 38′ 02″
7317	N	"	1	20	57	02	45° 47′ 55″
7333	S	IV	3	20	59	28	46° 40′ 06″
7402	S	VI	2	21	12	52	46° 40′ 59″
7705	N	"	3	21	59	56	45° 42′ 51″

The table is continued, as above, until 20° to 25° from the zenith is reached. It contains the information necessary to apply the foregoing rules for selection. The pains which may be bestowed on this table are not lost. Some of the observers prefer, in filling it up, to take zones of five degrees at a time, on each side of the zenith, and to go through the catalogue thus, several times within the limits of the AR determined upon.

The pairs, then, are selected, and placed according to the right ascensions, as in the following table:

TABLE No. II.

For Selection of Pairs for Observation with the Zenith Telescope. From 17*h.* *to* 19*h.*

Stars.	N. or S.	Mag.	Auth.	A. R.			N. P. D.		
6238	S	VI	3	18*h*	15*m*	10*s*	61°	11′	52″
6289	N	V	3	18	21	43	31	17	07
6179	N	III½	3	17	50	56	33	06	09
6147	S	V½	3	18	01	20	59	27	23
6178	S	V	3	18	06	10	58	37	40
6184	N	VI	1	18	07	21	33	45	58
6368	N	VI	2	18	35	35	34	53	24
6427	S	VI	3	18	44	17	57	37	07
6091	N	II	5	17	53	08	38	29	29
6235	S	IV½	3	18	14	37	53	59	59

From 19*h.* *to* 21*h.*

Stars.	N. or S.	Mag.	Auth.	A. R.			N. P. D.		
				h.	m.	s.	°	′	″
7008	S	VI	1	20	14	49	51	04	03
7076	N	VII	3	20	23	53	41	34	42
6983	N	IV½	3	20	10	50	42	44	38
6956	S	V½	2	20	12	48	49	43	59
7277	S	IV	3	20	51	35	49	24	29
7301	N	V½	3	20	54	43	43	03	45
7100	S	VI	1	20	27	39	47	19	05
7171	N	I	5	20	36	19	45	15	12
7317	N	VI	1	20	57	03	45	47	55
7333	S	V	3	20	59	29	46	40	06
6851	S	V	3	20	50	41	55	18	47
6928	N	V½	1	20	02	16	37	16	42
6932	N	V	3	20	03	09	28	26	20
6944	S	VI	3	20	05	43	63	57	55
7001	S	VI	1	20	13	30	51	27	48
7062	N	V½	3	20	22	27	41	06	45
7132	S	V½	4	20	31	27	58	59	51
7189	N	VI½	2	20	38	33	33	09	09
6571	S	VI	2	19	06	01	58	57	45
6583	N	V	3	19	08	50	33	23	41

NUMBER III.

Pairs Selected for Observation.

No. of Pair.	Star.	N. or S.	Mag.	Auth.	AR.			N. P. D.			△+△′		Z−Z′		ZD.	
					h.	*m.*	*s.*	°	*′*	*″*						
1	6109	N	VI	3	17	55	39	44	29	23	92°				1°	46′
	Time μ' Sagittarii at				18	04	46									
	6203	S	VI	1	18	10	59	47	53	21	22′	44″	−6	16	1°	38
	Time α Lyræ				18	31	51									
	6599				19	11	09									
	δ Aquilæ				19	17	55									
2	6681	N	VI½	3	19	23	04	32	16	29	27	53	−1	07	13	59
	6740	S	IV	3	19	33	27	60	11	24					13	56
3	6771	S	V	3	19	38	53	53	00	19	30	19	+1	19	6	45
	6865	N	VI	1	19	52	38	39	30	00					6	45
4	6937	S	V	3	20	03	51	53	35	56	35	08	+6	08	7	20
	6959	N	V	1	20	08	22	38	59	12					7	16
5	7001	S	VI	1	20	13	29	51	27	51	34	39	+5	39	5	12
	7062	N	V½	2	20	22	27	41	06	48					5	09
	Time 61′, Cygni				21	00	11									
6	7398	S	IV½	4	21	11	31	51	13	58	21	23	−7	37	4	59
	7411	N	VI	1	21	14	18	41	07	25					5	08
	Time β Aquarii				21	23	39									

From the table No. II, the pairs which best fulfill the conditions heretofore stated, are selected, and the difference between twice the co-latitude of the place and the sum of polar distances, is entered with its proper sign, $\left(180°-2L-(\triangle_n+\triangle_s)\right)$ this quantity being equal to the difference of the zenith distances of the two stars composing the pair, (since $180°-2L=\triangle_n+\triangle_s+Z_n-Z_s$, L being the latitude $\triangle_n$ and $\triangle_s$ the polar distances of the star N. and S. of the zenith respectively, and Z_n and Z_s the zenith distances of the same star.)

The object of obtaining the zenith distances approximately, is, so to select the pairs that the sum of all their differences, with their proper signs, shall be nearly zero; which, as before stated, corrects for any error in the determinations of the micrometer values which are used in the observations.

$\Sigma Z - \Sigma Z^1 = 2'\ 41''$ *for* 17 *pairs.*

No. of Pair.	Star.	N. or S.	Mag.	Auth.	AR.	N. P. D.	$\triangle + \triangle'$	$Z - Z'$	ZD.
					h. m. s.	° ′ ″		′ ″	
1	6109	N	VI	3	17 55 39	44 29 23	92°		1° 46′
	Time, μ' Sagittarii at				18 04 46				
	6203	S	VI	1	18 10 59	47 53 21	22′·44″	−6 16	1 38
	Time,		α Lyræ ...		18 31 51				
			6599		19 11 09				
			δ Aquilæ ..		19 17 55				
2	6681	N	VI½	3	19 23 04	32 16 29			13 59
	6740	S	IV	3	19 33 27	60 11 24	27 53	−1 07	13 56
3	6771	S	V	3	19 38 53	53 00 19			6 45
	6865	N	VI	1	19 52 38	39 30 00	30 19	+1 19	6 45
4	6937	S	V	3	20 03 51	53 35 56			7 20
	6959	N	V	1	20 08 22	38 59 12	35 08	+6 08	7 16
5	7001	S	VI	1	20 13 29	51 27 51			5 12
	7062	N	V½	2	20 22 27	41 06 48	34 39	+5 39	5 09
	Time, 61′, Cygni, ..				21 00 11				
6	7398	S	IV½	4	21 11 31	51 13 58			4 59
	7411	N	VI	1	21 14 18	41 07 25	21 23	−7 37	5 08
	Time, β Aquarii,...				21 23 39				
7	7598	N	V	3	21 41 15	41 23 03			4 52
	7614	S	VI	1	21 44 52	51 09 56	32 59	+3 59	4 54
8	7803	S	VI	1	22 15 38	47 00 37			0 45
	7894	N	VI½	3	22 31 48	45 35 50	36 27	+7 27	0 40
9	153	N	IV	3	00 28 38	36 55 50			9 20
	158	S	VI	3	00 29 20	55 25 43	21 34	−7 26	9 10
10	226	N	VI	1	00 41 13	43 03 18			3 12
	283	S	VI	3	00 54 29	49 27 54	31 12	+2 12	3 12
11	318	S	V	3	00 59 25	46 51 35			0 36
	352	N	VI	3	01 03 54	45 27 50	19 25	−9 35	0 47
12	487	N	III½	3	1 28 48	42 08 06			4 07
	502	S	V	3	1 31 44	50 11 13	19 19	−9 41	3 56
13	649	S	V½	3	1 59 27	52 51 20			6 36
	673	N	V½	3	2 03 38	39 38 07	29 27	+0 27	6 37
14	706	N	V	3	2 09 37	43 18 55			2 57
	727	S	V	3	2 13 31	49 17 18	36 13	+7 13	3 02
15	819	N	VI	1	2 32 26	37 07 08			9 08
	877	S	V½	3	2 42 16	55 33 47	40 55	+11 55	9 18
16	915	S	V½	2	2 49 45	55 25 27			9 10
	947	N	III½	3	2 53 57	37 05 11	30 38	+1 38	9 10
17	953	S	IV	3	2 55 34	51 44 44			5 29
	1043	N	II½	4	3 13 37	40 40 42	25 26	−3 34	5 35

Sum + 47′ 57″
" − 45′ 16″
$\Sigma Z - \Sigma Z' = +$ 2′ 41″

The places of the stars are next accurately worked up by the method laid down in the preface to the B. A. C.

The forms used for computing the observations with the zenith telescope are shown, in the annexed tables. There are briefer methods; but this one has the advantage that all the quantities are spread out in the table, so that a second computer (the office computer) who differs from the first (the field computer) may trace, readily, the source of discrepancy.

DATE.	No. * B. A. C.	N. or S.	Micrometer. Turns.	Micrometer. Divis.	Diff. Z. D. By Mic.	Diff. Z. D. Arc.	1850—Sum of Polar Distances.	Twice Approx. Latitude.	Levels. N.	Levels. S.	State of level.	Merid. Dist.	Red. to Merid.	CORRECTIONS. Level.	CORRECTIONS. Merid.	CORRECTIONS. Refrac.	Twice Int.	Latitude
1849.																		
Sep. 20	6983	N	5	30·2			42 44 20·04										87° 30′	43° 45′
	6996	S	4	15·0	−115·2	−0′ 51″·86	49 43 41·46	87°	58·0	34·6							68	34″·39
							92 28 01·50	30	66·6	95·0	90·2	+ 4·8				−0·02	77	
							87 31 58·50											
	6983	N	4	91·5			42 44 19·87		45·1	46·2								
" 21	6996	S	3	85·3			49 43 41·30		41·2	50·2								
					−105·2	−0′ 47·81	92 28 01·17	30	71·0	86·3	96·4	− 10·1						
							87 31 58·83											
	6983	N	8	3·0			42 44 19·30		47·0	38·0								
" 25	6996	S	6	91·3			49 43 40·79		38·0	47·0								
					−111·7	−0′ 50·29	92 28 00·09	30	69·0	85·0	85·0	− 0·0						
							87 31 59·91											
	6983	N	5	88·8			42 44 19·04		41·0	56·0								
" 27	6996	S	4	79·0			49 43 40·56		57·0	40·0								
					−109·8	−0′ 49·43	92 27 59·60	30	70·0	97·0	96·0	+ 2·0		+0·90		−0·02	71	85	35″·92
							87 32 00·40										Mean	=34″·58

In discussing the results of the observations, the first step is to ascertain the probable error of observation. For this purpose, the latitude which results from each observation, on each pair of stars, is compared with the mean latitude, from all the observa-

tions on that pair. If the observations were numerous, of course the probable accidental error would be thus obtained with more precision than in the actual case.

The following table gives a convenient form for applying this method. The results were obtained by one of the sub-assistants in the U. S. Coast Survey, at Mount Independence, with the Zenith Telescope of the Coast Survey, No. 3.

For Probable Error of a Single Observation.

No. of Pairs.	Results for Latitude.	x	$(a-x)$	$(a-x)^2$	SUMMARY.	
I	37·92					
					I, II, III, IV, sum of sqs.	10·9907
	35·71		1·79	3·2041	V, VI, VII,	10·5131
II	33·01		·91	·8281	VIII, IX, X,	6·0435
(4)	32·90		1·02	1·9400	XI, XII, XIII, XIV,	8·5117
	34·05		·13	·0169	XV, XVI, XVII, XVIII,	6·7534
		33·92			XIX, XX, XXI, XXII,	7·8312
	36·15		·05	·0025	XXIII, XXIV, XXV, XXVI,	7·3678
III	27·84		1·64	2·6896	XXVI, XXVII, XXVIII,	5 5054
(4)	34·59		1·61	2·5921	XXIX, XXX, XXXI,	6·9242
	36·23		1·03	·0009	XXXII, XXXIII,	2·3263
		36·20				
	42·41		·67	·4489	$\Sigma(a-x)^2 = 72·7673$	
IV	41·44		·36	·0900		
	41·50		·24	·0576		
(4)	41·60		·14	·0196		
		41·74				
	31·97		·28	·0784		
V	32·80		·55	·3025		
(5)	32·55		·30	·0900		
	31·44		·81	·6561		
	32·48		·23	·0529		
		32·25				
	29·81		1·39	1·9321		
	28·22		·20	·0400		
VI	28·11		·31	·0961		
(5)	26·72		1·70	2·8900		
	29·24		·82	·6724		
		28·42				
	34·39		·19	·0361		
	33·23		1·35	1·8225		
VII	34·80		·22	·0484		
	35·92		1·34	1·7956		
(4)		34·58				
				21·5038		

Number of observations, $x=150$

" " pairs, $v=32m^2=\Sigma\left(\frac{a-x}{x-v}\right)^2=\frac{72·7673}{118}=0·6167$

$x-v=\overline{118}$

Then $0·6167=\Sigma(a-x)^2$ on a single pair having but a single observation upon it.

The probable error of one observation $=\sqrt{·4549\times0·6157}=$ 0″·53

" " " " the result of a pair having three observations upon it, ... 0·31

For four observations upon a pair, ... 0·27

" five " " " . . . . . 0·24

" six " " " . . . . . 0·22

" seven " " " . . . . . 0·20

From this, results the mean probable error of any number of observations upon a pair of stars, by dividing the value just found by the square root of the number of observations.

We are now prepared to estimate the error of the places of the stars used; for the discrepancies which they show are composed of errors of observation and of errors of the catalogue,* if the computations have been rightly made. The form in which this discussion is made is given in the annexed table, with the results.

Number of Pairs.	Number of Star in B. A. Catalogue.		Mean of each pair. x	Mean latitude. a	$a \frown x$	$(a \frown x)^2$
I	6368	6427	37·92	34″·50	3·42	11·6964
II	6497	6522	33·92		·58	·3364
III	6571	6583	36·20		1·70	2·8900
IV	6673	6712	41·74		7·24	52·4176
V	6745	6754	32·25		2·25	5·0625
VI	6851	6928	28·42		6·08	36·9664
VII	6983	6996	34·58		1·23	·0064
VIII	7008	7076	33·27		·08	1·5129
IX	7100	7171	34·55		·05	·0025
XXXIII	953	1043	35·12		·62	·3846
		33	1138·66	$\Sigma(a-x)^2$		169·6906
Mean lat. $=43°\ 45'\ 34''·50$					ΣM^2	4·4418
					Diff.....	165·2488

For $x-1$ pairs.

$$e^2 \text{ Catalogue} = \frac{\Sigma(a-x)^2 - \Sigma M^2}{x-1} = \frac{165·2488}{32} \quad \begin{matrix} \text{Log.} = 2·21814 \\ \text{“} = 1·50515 \end{matrix}$$

$$0·71299$$

$$·4549 \text{ “} = 9·65792$$

$$e^2 \text{ Cat.} = 0·37091$$

$$e \text{ Cat.} = 1''·53 = 0·18545$$

Probable error of position of one pair of stars, given in B. A. Catalogue, . . . $=1''·53$

The omission of the observations on the four pair of stars having the greatest probable error, would reduce the average Catalogue error of each pair to $0''·95$, and alter the mean latitude but $0''·05$. The omission of five pairs, having the next greatest probable errors, would but slightly change the probable error of the Catalogue, (to $0''·93$), while it would affect the mean latitude $+0''·32$. The effect of a few very discordant results on the probable error is not peculiar to these results, or confined to this class of observations.

A general comparison of the results obtained in the Coast Survey,—as I propose, on some other occasion, to show,—confirms

* This supposes the error of micrometer value to be too small to enter into the discussion.

the conclusion here deduced, that the weak point of this method is in the Catalogue places of the small stars used. The steps which have been taken to obtain determinations of these, in connection with the Survey, I hope, also, to bring before the Association. In the meanwhile, we multiply the number of pairs of stars, and make a number of observations on each pair; which would keep our results in due relation to those of the Catalogue, if much more perfect than at present.

ART. XXIII.—*Contributions to Analytical Chemistry;* by WOLCOTT GIBBS, M.D.

IN an interesting memoir* on the analogy between the chemical relations of peroxyd of lead and the so-called ozone, Schönbein has pointed out the remarkable fact that peroxyd of lead precipitates manganese completely from its solutions in chlorhydric and sulphuric acids, a compound of peroxyd of lead and peroxyd of manganese being formed. A portion of the lead is at the same time reduced to protoxyd and unites with the acid with which the manganese was combined: the oxydizing action which takes place may be represented by the general equation

$$PbO_2 + MnO.XH = MnO_2 + PbX + HO.$$

Schönbein appears not to have remarked the importance of this observation in an analytical point of view. In investigating the subject carefully I have been led to the conclusion that the peroxyd of lead constitutes one of the most valuable reagents in analytical chemistry, since by means of it the oxyd of manganese may be easily and completely separated from a number of other bases without the employment of ammoniacal salts. The use of ammonia, as is well known, frequently renders analyses conducted by the ordinary methods laborious and inaccurate, either from the number of operations involved, from the absorption of carbonic acid from the air, or from the unavoidable loss in driving off the ammoniacal salts by heat. The facts which I have determined and which serve as the basis of the analytical applications of the peroxyd of lead are as follows.

1. Peroxyd of lead completely precipitates manganese from its neutral solutions in chlorhydric, sulphuric, and nitric acids, slowly in the cold, but very rapidly by digestion or by boiling.

2. The presence of an excess of chlorhydric or sulphuric acid does not prevent the complete precipitation of the manganese; in these cases, however, chlorine or oxygen is set free, and the quantity of lead dissolved is greater than that which corresponds to the quantity of manganese precipitated. Such an excess of acid should be avoided as far as possible.

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* Pogg. Ann., lxxviii, 162.

3. The presence of an excess of nitric acid prevents the precipitation of the manganese, since, as Crum long since showed, hypermanganic acid is formed and remains in solution.

4. Tartaric acid and those organic substances which are burned at the expense of the peroxyd of lead, do not interfere with the precipitation of the manganese. The organic matter is first destroyed by the oxygen of the peroxyd of lead, and afterward the manganese is precipitated by the excess of the peroxyd added. When the quantity of organic matter present is large it is always better to separate the manganese by means of sulphydrate of ammonium in the usual manner.

5. When, however, oxalic acid is present, we may avoid the use either of an inconvenient quantity of peroxyd of lead, or of sulphydrate of ammonium, by means of chlorine or bromine. Either of these agents readily converts oxalates into carbonates by a well known reaction, $RO, C_2O_3 + Br = RrB + 2CO_2$.

6. The presence of an excess of free acetic or succinic acid does not prevent the complete precipitation of manganese by peroxyd of lead.

7. The same observation applies to the presence of sulphate, nitrate, and chlorid of ammonium, and therefore, probably, to all ammoniacal salts.

8. Salts of protoxyd of iron are oxydized and partially precipitated by peroxyd of lead.

9. The same remark applies to the salts of cobalt. The precipitation is not complete even after long digestion upon the sandbath.

10. The salts of nickel and zinc are not precipitated by peroxyd of lead, and the nickel undergoes no higher oxydation.

11. Peroxyd of lead when perfectly free from protoxyd does not precipitate baryta, strontia, lime, magnesia, or alumina from their solutions. The same remark applies as might be supposed, à fortiori, to the alkaline bases. The application of these facts to the quantitative separation of manganese from the above mentioned bases, with the exception of iron and cobalt, is obvious. The different cases deserve however to be considered separately.

Manganese from potash and soda.—Peroxyd of lead is to be added to the neutral solution of the three bases in chlorhydric, nitric or sulphuric acid; the whole is then to be digested upon the sandbath for an hour at a temperature of 85° C., care being taken to agitate the solution frequently and thoroughly with a glass rod. For every gramme of matter analyzed it is well to employ about five grammes of peroxyd of lead. After digestion the solution is to be filtered and the mass upon the filter thoroughly washed with hot water. The filtrate contains the alkaline bases and lead, but is absolutely free from manganese. The lead is to be separated by means of a current of sulphuretted

hydrogen, and in the filtrate from the sulphide of lead the alkalies are to be determined in the usual manner; as there are no ammoniacal salts present the estimation of the alkalies offers no difficulty when they are in the form of chlorids. When but a single alkali is present its quantity may be determined by simple evaporation to dryness and ignition. The mass upon the filter after washing consists only of the peroxyds of lead and manganese. The filter is to be dried, ignited gently in a porcelain crucible, and then heated with fuming nitric acid which speedily produces a colorless solution. This is to be diluted sufficiently with water and the lead separated by sulphuretted hydrogen. The filtrate from the sulphide of lead contains only manganese which may then be determined as usual by carbonate of soda. In the above process it is almost always best to reduce the bases to be separated to the form of chlorids. The separation of the lead is much less easy when sulphates are present, while on the other hand the presence of nitric acid renders it difficult subsequently to determine the alkalies. When however but one alkali is present with manganese, we may employ a solution of the nitrates, since in this case the alkali after the separation of the lead may be estimated by fluosilicic acid and alcohol, as recommended by Rosé. When the solution of the bases is acid it may be neutralized with carbonate of lead, but this should be avoided if possible, since it is not desirable to introduce more lead into the solution than is absolutely necessary.

When, as is generally the case in mineral analyses, iron is associated with manganese and the alkalies, it is most advantageous to peroxydize the iron by means of chlorine or bromine, and then to separate it from the other bases by means of carbonate of baryta. After the separation of the iron, the manganese may be separated from the alkalies by the methods above given, the presence of a salt of baryta not interfering in the process.

Separation of manganese from baryta, strontia, lime, magnesia and alumina.—The separation of manganese from these bases may be effected by the same process as that given above for its separation from the alkalies. When the alkalies are also present in the solution, all the bases should be if possible in the form of chlorids. When this is not the case, however, it is most convenient to employ the bases in the form of nitrates, avoiding the least excess of free nitric acid. After the digestion upon the sandbath and before filtering, it is well to add a few drops of nitric acid, when magnesia or alumina are present; the acid however should only be added after the solution has become nearly cold and when no alkalies are present. When iron is also present but no alkalies, we may peroxydize and precipitate it by ammonia, and then separate the manganese from the filtrate by means of peroxyd of lead. In this case of course the precipitated per-

oxyd of iron also contains manganese which must be separated in the usual manner. When however the alkalies are present, we may separate the iron and alumina by means of carbonate of baryta, and then determine the manganese as above, thus avoiding the presence of ammoniacal salts in the solution.

Separation of manganese from zinc and nickel.—The processes to be followed in this case are the same as in the last. The addition of a few drops of nitric acid to the solution after digestion and cooling is advantageous, as the precipitation of a trace of zinc or nickel by any minute quantity of *protoxyd* of lead which may be present is prevented. The peroxyd of lead is a reagent of especial value for the separation of manganese from zinc, but is less serviceable where manganese is to be separated from nickel, since this metal is usually associated with cobalt. When cobalt and nickel are both to be separated from manganese, Ebelman's method appears preferable to any other. From what has already been stated (8 and 9) it will be evident that the peroxyd of lead cannot be employed to separate manganese from iron and cobalt. On the other hand, however, it is highly probable that this reagent will effect the perfect separation of manganese from glucina, zirconia, and the metals of the cerium group. But upon this point the writer cannot speak from actual experiment.

For the analysis of a mineral which contains silica, alumina, oxyd of iron, manganese, lime, magnesia, and the alkalies, I propose the following process which appears, a priori, likely to prove advantageous. The silica is first to be separated in the usual manner by chlorhydric or fluohydric acid. The solution of the bases, after peroxydizing the iron, is to be treated with carbonate of baryta to separate alumina and iron. To the filtrate from these bases peroxyd of lead is to be added to separate the manganese. The filtrate, after separating the lead by means of sulphuretted hydrogen, will then contain baryta, lime, magnesia, and the alkalies, which are to be separated in the usual manner. By this method we may avoid in a great measure, if not entirely, the presence of ammoniacal salts, and obtain more accurate determinations of the lime and manganese than by the ordinary process.

As the investigations which form the subject of the present paper have been chiefly of a qualitative character, it was a matter of especial importance to the writer to possess a sufficiently delicate test for manganese. Crum's test offered of all others the greatest advantages; but as in the original paper in which this test is described it is simply stated that the reaction is a very delicate one, and as the circumstances which modify or prevent its process are not alluded to, it became necessary to make this point the subject of special study. The results obtained in this investigation are as follows:

1. By means of Crum's test it is easy to detect the presence of the $\frac{1}{10000}$ of manganese in a solution otherwise colorless. With proper care a much smaller quantity of the metal may be detected, but the above will form a good *practical* limit to the sensibility of the reaction.

2. The manganese in this reaction may be present as chlorid, nitrate, sulphate or phosphate, without effecting the result.

3. The presence of sulphate or nitrate of ammonium even in very large excess does not sensibly affect the delicacy of the reaction.

4. The presence of chlorid of ammonium in small quantity does not affect the reaction. When, however, the chlorid is present in great excess, it is necessary to add a very large proportion of peroxyd of lead in order to obtain the characteristic rose or violet tint, as the lead is reduced to a chlorid so long as there is sal-ammoniac in the solution. In this case, therefore, it is better to precipitate the suspected liquid by sulphydrate of ammonium, and then to test the precipitate by nitric acid and peroxyd of lead.

5. When organic substances are present, the solution should either be evaporated to dryness and ignited, or else precipitated by sulphydrate of ammonium, and the precipitate tested. The first method would probably answer best in testing mineral waters.

6. The bases to be tested for manganese may be present as nitrates, sulphates, or chlorids. In the latter case the characteristic violet or rose color makes its appearance, even though chlorine is copiously evolved from the solution, on boiling with the nitric acid and peroxyd of lead.

7. The presence of iron even in large excess does not very sensibly affect the delicacy of the reaction.

8. The presence of an excess of a salt of nickel completely prevents the reaction for manganese, the violet color of the hypermanganic acid being lost in the green of the nickel compound.

9. The presence of a small excess of a salt of cobalt does not materially affect the reaction for manganese. It is, however, impossible by the direct application of Crum's test to detect the presence of a small quantity of manganese in a large quantity of a cobalt compound.

10. The difficulty which arises in the application of Crum's test when cobalt or nickel is present, may be completely avoided by the following process, which is based upon the observation of Maumené that the colors of solutions of cobalt and nickel are complementary to each other. The solution of cobalt which is suspected to contain manganese, is first to be freed as completely as possible from arsenic, copper, and iron. To a portion of this solution contained in a test tube, a solution of a pure salt of nickel is to be gradually added until the color of the mixed fluid vanishes or becomes almost insensible. Nitric acid and peroxyd

of lead are then to be added, and the whole boiled for a few seconds, when the characteristic tint will appear if but a trace of manganese be present. The same process is to be applied in testing solutions of nickel for small quantities of manganese, a pure solution of cobalt being added till the original green color of the solution is destroyed. It rarely happens in the application of this method that a perfectly colorless solution can be obtained; usually the mixed solution has a faint brown tinge like that of commercial sulphuric acid. This tint, however, has no sensible influence on the result.

11. In all cases in which Crum's test is employed the color of the liquid must be observed immediately after boiling and subsidence of the excess of peroxyd of lead, as the tint fades when the solution is exposed to air and light.

The constitution of the black substance which is precipitated from solutions of manganese by peroxyd of lead has not yet been satisfactorily determined, in consequence of the difficulty of obtaining it perfectly free from an excess of peroxyd of lead, and I propose to resume the subject in another paper. It appears, as stated by Schönbein, to be a chemical combination of the peroxyds of lead and manganese; its chemical relations are as follows:—Chlorhydric acid readily dissolves it, even in the cold; the solution has a dirty brown color, and evolves chlorine copiously on heating, becoming colorless. Red and fuming nitric acid gradually dissolves it with the aid of heat; ordinary nitric acid, nearly free from nitrous acid, dissolves but a very small portion even after long digestion. Sulphuric acid has no action in the cold, but on heating evolves oxygen, while sulphate of lead is found. Oxalic and tartaric acids are readily oxydized by digestion with the black compound, with evolution of carbonic acid, and formation of carbonates of lead and manganese.

In another memoir I shall return to this subject and give the results of quantitative analyses, conducted according to the methods pointed out in the present communication. It may be proper to state in conclusion, that the peroxyd of lead employed in the above mentioned investigations was obtained by the action of chlorine upon hydrate of protoxyd of lead suspended in water. The resulting mixture of chlorid and peroxyd was thoroughly washed with boiling water to separate the chlorid, and then repeatedly digested with nitric acid to remove every trace of protoxyd of lead, washed and dried. As thus prepared the peroxyd is very dark brown, or nearly black; the commercial peroxyd, which is prepared by the action of nitric acid upon minium, cannot be used either in qualitative or quantitative analysis, as it contains iron and manganese as well as the other impurities of the minium employed.

New York, July 18th, 1852.

ART. XXIV.—*On Certain Analogies in the Solar System;* by Professor DANIEL KIRKWOOD, of Delaware College.

I. *The Rotations of the Planets.*—When we compare the distances of the planets with their times of orbitual revolution, we cannot fail to observe that a greater period always corresponds to a greater mean distance—suggesting at once the important fact, that the former varies according to some function of the latter. This is the great truth which underlies the celebrated third law of Kepler. The case is very different, however, when we come to compare the periods of rotation. Here no order or connection is at first apparent. Jupiter, the first planet exterior to the asteroids, is the *largest* in the system, and has the *shortest* period of rotation. Mars, the next *interior* to this group, is, with the exception of Mercury, the smallest of the eight principal planets, and is the *longest* in completing its diurnal revolution. Saturn, whose diameter is rather *less* than that of Jupiter, has a *longer* time of rotation; while Venus, whose volume is somewhat less than that of the Earth, revolves on its axis in a *shorter* period. Again: Venus, the planet next *interior* to the earth's orbit, and Mars, the first *exterior*, have nearly the same density; while the rotation period of the one is forty minutes *less*, and of the other forty minutes *greater* than that of our planet. Thus whether we compare the masses, volumes, or distances of the planets, we find the same apparent independence in regard to their rotations. This fact has been noticed by various writers. "We know as yet," says Humboldt, "of no inherent necessity, no mechanical, natural law, similar to the one which teaches us that the squares of the periodic times are proportional to the cubes of the major axes, by which the above named six elements* of the planetary bodies and the form of their orbit are made dependent either on one another, or on their mean distance from the Sun."† "There is no apparent reason," remarks another distinguished writer, "why this globe should turn on its axis just three hundred and sixty-six times while it describes its orbit round the Sun. The revolution of the other planets, so far as we know them, do not appear to follow any rule by which they are connected with the distance from the sun. Mercury, Venus, and Mars have days nearly the length of ours. Jupiter and Saturn revolve in about ten hours each. For any thing we can discover, the earth might have revolved in this or any other smaller period; or we might have had, without mechanical inconvenience, much longer days than we have."‡

* Viz.: "Their absolute size, density, period of rotation, eccentricity, and the inclinations of their orbits and the axes." † Cosmos, vol. i, p. 77.

‡ Whewell's Astronomy and General Physics, p. 27.

Again, "we cannot see anything which could have prevented either the size or the density of the earth from being different, to a very great extent, from what they are."*

The first attempt, so far as I know, to develop a connection between those apparently independent elements, was made by the writer a few years since. Finding, generally, that law and harmony characterize the operations of nature around us, I have ever thought it extremely improbable, since my attention was first turned to the subject, that the Creator had, in this instance, departed from his ordinary mode of action. The result of these efforts has been now nearly three years before the public, and has attracted some degree of attention. The most recent notice with which it has been honored is that of Professor Cherriman, whose article in the last number of the *American Journal of Science and Arts* has suggested the propriety of a brief re-discussion of all the known facts which have an immediate and obvious bearing upon this interesting subject.

The quantities to be used in our examination, it will be observed, are extremely various. Thus Jupiter's mass is about 3,000 times greater than Mercury's; the interval between Saturn and Uranus when in conjunction is 33 times greater than that between Venus and the Earth in similar circumstances; and the number of Saturn's days in his year is 280 times greater than the number of Mercury's. If, therefore, all the known elements of the solar system, so far as applicable, consisting of magnitudes so widely different, harmonize together in a complicated formula, is it not, to say the least, extremely probable that this formula is the expression of a law of nature?

In the able "examination" of my analogy by Sears C. Walker, Esq.,† a numerical error in Jupiter's time of rotation was admitted. In constructing the following table I have, besides correcting this mistake, used masses somewhat different from Walker's. It is well known that there is some uncertainty in regard to the quantity of matter in several of the planets: an *exact* agreement with all the *received* values is therefore not to be expected. All that can be demanded is an approximation so close as to come within the limits of error of the masses. The distances, sidereal revolutions, and axial rotations which I have employed are those used by Professor Loomis.‡ I have adopted Encke's masses of the Earth, Jupiter, and Saturn; the last, however, may hereafter require some slight modification. For Uranus, I have employed the latest determination, that of Struve, from

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* Whewell's Astronomy and General Physics, p. 32.

† See this Journal, [2], x, 22.

‡ Ibid. [2], xi, 219. In Loomis's table the mass of the Earth alone was erroneously used instead of the sum of the masses of the Earth and Moon.

his observations in 1848. The resulting diameter of Saturn's sphere of attraction is

$$D = 8{\cdot}618608,$$

and the corresponding value of the constant of rotation is

$$\frac{n}{D^{\frac{3}{2}}} = C = 972{\cdot}929,$$

where $n =$ the number of axial rotations performed during one revolution round the sun. The values of D for the other planets whose periods of rotation are known, are then determined from the formula

$$log.\ D = \frac{2}{3}(log.\ n - log.\ C).$$

If we assume that the adopted values of m for Jupiter, Saturn and Uranus are entirely correct, the received masses of Mercury, Venus, and Mars will not perfectly harmonize with my analogy. My tabular masses of the two latter differ from the received masses by about one-seventeenth of their values. That of Mercury differs from Leverrier's mass by about one-fiftieth. Are these interpolated masses admissible?

It is distinctly stated by Humboldt that these elements for the three planets mentioned probably need correction.* "The masses of Mercury and Venus," says Captain Smyth,† "are still subject to discussion, since the question is surrounded by every difficulty, as neither of them has a satellite." In regard to Mars, Mr. Hind remarks, that "in the absence of a satellite to afford us a more exact value, we can only be said to have *approximated* to the mass of the planet."‡ It is unnecessary to quote other authorities. That the received mass of each of these planets may be in error to the amount of one-seventeenth of its value, will hardly be called in question.

To interpolate the elements of the asteroid-planet, we have the equations:—

$$\frac{\mu}{\varrho'^2} = \frac{M}{R^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$\frac{\mu}{\varrho_{,}^{\,2}} = \frac{m}{r^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

$$\Delta = \varrho' + \varrho_{,} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

$$\delta = d + r + \varrho_{,} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

whence

$$\varrho_{,} = \frac{r\Delta\sqrt{M}}{r\sqrt{M} + R\sqrt{m}},$$

* Cosmos, vol. iv, pp. 445, 472, 503.
† Cycle of Celestial Objects, vol. i, p. 106.
‡ Hind's Solar System, p. 78.

$$\mu = m\left(\frac{\varrho_i}{r}\right)^2,$$

$$\delta = d + r\left(\frac{\Delta\sqrt{\mathrm{M}}}{r\sqrt{\mathrm{M}} + \mathrm{R}\sqrt{m}} + 1\right),$$

where

m = the mass of Mars,
μ = " the asteroid planet,
M = " Jupiter,
r = the outer radius of Mars's sphere of attraction,
R = the inner " Jupiter's " "
Δ = the diameter of the asteroid planet's sphere of attraction,
ϱ' = the outer radius " " " "
ϱ_i = the inner " " " "
d = the mean distance of Mars from the sun,
δ = " " the asteroid planet from the sun.

If the asteroids, however, are considered as independent planets, the analogy is still applicable to Mars and Jupiter: Flora, the nearest of those bodies, being immediately exterior to the outer limit of Mars's sphere of attraction; and the mean distance of Hygeia, the most remote, nearly corresponding with the interior limit of that of Jupiter.

TABLE I.

Planetary Elements conforming with Kirkwood's Analogy.

Planet.	Mean Distance.	Distance to next exterior orbit.	Mass.	Period.	Rotation.	Diam. of Sph. of attraction.	Outer Radius.	Inner Radius.
	d	b	m	P	p	D	r'	r_i
				d.	*h. m. s.*			
Mercury,	·03870981	·3362335	$\frac{1}{2934873}$	87·96925	24 5 28·3	·200975	·088919	·112060
Venus,	·7233316	·2766684	$\frac{1}{379515}$	224·7007869	23 21 21·9	·383396	·136076	·247314
Earth,	1·0000000	·5236923	$\frac{1}{355499}$	365·256361	23 56 4·09	·521348	·380756	·140592
Mars,	1·5236923	1·544983	$\frac{1}{2522609}$	686·979645	24 37 20·4	·779537	·636601	·142936
Ast. Planet	3·068675	2·134101	$\frac{1}{12386931}$	1969·		·968693	·060311	·908382
Jupiter,	5·202776	4·3360101	$\frac{1}{1047787}$	4332·5848	9 55 26·5	4·876551	2·802761	2·073790
Saturn,	9·538786	9·643604	$\frac{1}{3501\,6}$	10759·21	10 29 16·8	8·618603	7·085359	1·533249
Uranus,	19·18239	10·85711	$\frac{1}{2\,6\,8\,6\,0}$	30686·8208	37 19?	7·437871	4·879626	2·558245
Neptune,	30·03950		$\frac{1}{17900}$ *	60126·7000				

On the Application of this Analogy to Mercury.—The statement of Professor Cherriman that my analogy is inapplicable to Mercury is but partially correct: the *mass* and *distance* of this planet conform with the law in question. The inner radius of Mercury's sphere of attraction, however, extends to a considerable distance within the orbit. This would seem to indicate, (1) the existence either of a planet or a ring of minute asteroids interior to Mercury's orbit; or, (2) that the original nebulous ring was from some cause precipitated upon the sun. For several

* Hind's value, found by a combination of all the observations of the satellite. (See Hind's Solar System, p. 136.)

years I have had a growing belief that Mercury is not the nearest planet to the center of our system. This conjecture was first suggested by the fact that the ratio of the sun's diameter to Mercury's distance is much greater than that of the diameter of any planet to the distance of its nearest satellite. My confidence in the existence of such a body was strengthened by the discovery of the analogy in the periods of rotation of the planets. The distance from the center of the sun to the limit at which the centrifugal and centripetal forces would be in equilibrium is ·168; that to the inner limit of Mercury's sphere of attraction, ·275. Hence the probability that in this interval there may be an undiscovered planet. The existence of this hypothetical body seems also to be indicated by a certain order found to prevail in the arrangement of the planetary masses. This will be referred to hereafter. Upon the whole, I cannot but regard the probabilities as sufficiently strong to justify some search for the planet. Admitting its existence, an interesting question arises in regard to its perturbative influence on Encke's comet. Perhaps the diminution in the period of the latter might in this way be at least partially accounted for.

Application to the Asteroids.—If it be asked, what is the bearing of this analogy on the *Olbersian* hypothesis of the origin of the asteroids?—I answer, it does not essentially require that those bodies should ever have been united in *one* perfect planet. It merely indicates what *would have been* the mass, mean distance, and time of rotation of the resulting planet, had all the matter in the primitive ring collected about a single nucleus. If, however, we admit the hypothesis of an explosion, may we not likewise suppose a subsequent disruption of some of the larger fragments? In this case it might be impossible to trace all the resulting asteroids to the first point of separation.

But it seems more probable that those small planets were formed by the separation of the primitive mass while in the nebular state, or at least previous to its solidification. This separation may have been produced by the perturbative influence of the other planets—chiefly that of Jupiter—either on the original ring, as suggested by Professor Peirce,* or on the asteroid-planet while in its primordial condition. In regard to the perturbations of this asteroid-ring, the following considerations may be worthy of notice:

1. Owing to the proximity of the asteroid-orbit to the enormous mass of Jupiter, the disturbance would be very much greater than in any other part of the planetary system.

2. The breadth of the ring, or the primitive diameter of the planet, was probably such that the influence of Jupiter on opposite sides would be very unequal.

* Gould's Astronomical Journal, No. 27.

3. The period, (1969 days according to Table I.) which my analogy assigns to the asteroid-planet, is almost exactly commensurable with that of Jupiter; eleven of the former being about equal to five of the latter.

4. If we assume that the period of Encke's comet has diminished uniformly at the present rate, the time of revolution, at no very remote epoch, was 1238 days; that is, seven of its periods were precisely equal to two of Jupiter's.

5. Among the swarms of minute asteroids which may be supposed to revolve in this zone, there have probably been many whose periods were commensurable with that of Jupiter. Those completing a revolution in 1444 days—precisely one-third of Jupiter's period—would be in conjunction with that planet, in the same point of the orbit once in every 4332 days. The consequence in such case would be a permanent derangement.

6. It is possible that in consequence of mutual attractions, intersections of orbits, &c., new combinations and aggregations of matter not unfrequently occur in this part of the planetary system. Important discoveries, I have no doubt, are yet to be made in regard to those mysterious objects.

When my analogy was discovered no asteroid had been detected beyond the orbit of Pallas. Since that time, however, two of those small bodies, Hygeia and Psyche, have been found at distances considerably greater: the orbit of the former being exterior to that of the primitive (hypothetical) planet, and that of the latter nearly coinciding with it. The mean distances, periods, and inclinations of the small planets, together with the date of the discovery of each, are as follows:

TABLE II.

Name.	Mean dist.	Period.	Inclination.	Date of discovery.	Discoverer.
Flora,	2·2018	1193*d*	5° 53′	1847, October 18,	Hind.
Clio,	2·3349	1303	8 23	1850, Sept. 13,	Hind.
Vesta,	2·3612	1325	7 8	1807, March 29,	Olbers.
Iris,	2·3855	1346	5 28	1847, August 13,	Hind.
Metis,	2·3862	1346	5 36	1848, April 25,	Graham.
Hebe,	2·4249	1379	14 47	1847, July 1,	Hencke.
Parthenope,	2·4483	1399	4 37	1850, May 11,	De Gasparis.
Thetis,	2·4612	1410	5 36	1852, April 17,	Luther.
Astræa,	2·5774	1511	5 19	1845, December 8,	Hencke.
Egeria,	2·5825	1516	16 33	1850, November 2,	De Gasparis.
Irene,	2·5849	1518	9 6	1851, May 19,	Hind.
Eunomia,	2·6476	1574	11 49	1851, July 19,	De Gasparis.
Juno,	2·6687	1592	13 3	1804, September 1,	Harding.
Ceres,	2·7673	1681	10 37	1801, January 1,	Piazzi.
Pallas,	2·7729	1687	34 37	1802, March 28,	Olbers.
Psyche,	3·0661	1961	3 30	1852, March 17,	De Gasparis.
Hygeia,	3·1514	2043	3 47	1849, April 12,	De Gasparis.

Application to Uranus.—The rotation-period of Uranus has never been determined by observation. With the masses adopted in Table I. it is found, according to my analogy, to be about

37 hours. It has been objected, however, that a more rapid rotation would seem to be indicated by Mädler's determination of the ellipticity. In addition to my remarks on this subject in a former number of this Journal,* I will merely state that Mädler's measurement has not been confirmed. "Other astronomers, with more powerful telescopes, have not succeeded in gaining any certain evidence of an appreciable difference in the diameters."† Mr. O. Struve states "that the grand refractor at Pulkova affords no indications of ellipticity." If any thing, therefore, can be inferred from the figure of Uranus, it is a *slow* rotation.

The objection that the rotation-period of this planet ought to be nearly equal to that of Jupiter or Saturn, because of the similarity of the three bodies in other respects, has certainly but little of reason or analogy to sustain it. It has been customary to regard the principal planets as arranged in two distinct groups, separated by the region of the asteroids. It has been stated that in magnitude, density, polar compression, &c., there is a striking uniformity between the members of each group, and hence it has been argued that in order to complete the similarity, we must suppose their rotatory velocities to be nearly equal. Now what are the facts in regard to this classification? Let us briefly examine.

The volume of the Earth or Venus is about seven times that of Mars, or nearly twenty times that of Mercury; while in the exterior group, the volume of Uranus or Neptune is less than one-tenth that of either of the other two major planets. Jupiter and Saturn are very much compressed at the poles, while the best telescopes in Europe afford no evidence of the ellipticity of Uranus or Neptune. Again: Venus and the Earth have greater masses compared with Uranus or Neptune, than these latter in comparison with Jupiter and Saturn. To any one who will compare the planetary elements other discrepancies cannot fail to present themselves.

II. *On the Arrangement of the Planetary Masses.*—We have seen that the classification of the planets into two groups is very far from exact. The following will be found more in harmony with nature: several considerations, moreover, seem to favor the presumption that it is not a mere unmeaning order, but a significant fact, whose explanation is to be referred to the theory of the system's formation. Its publication in this connection may not therefore be improper.

If we commence with Neptune, the most remote planet known, we shall find that the primary planets are arranged in PAIRS, the

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* [2], xi, pp. 394–398. Sir W. Herschel's opinion in regard to the figure of Saturn has been found erroneous.

† Hind's Solar System, p. 121. See also Main's Rudimentary Astronomy, p. 130.

members of which are nearly equal in diameter. This is exhibited in the second column of

TABLE III.

	Planets.	Mean diameter.	Density.
I.	Neptune,	4·739	·187
	Uranus,	4·428	·153
II.	Saturn,	9·205	·133
	Jupiter,	11·255	·243
III.	Ast. Planet,	·584 ?	1·472 ?
	Mars,	·519	1·032
IV.	Earth,	1·000	1·000
	Venus,	·991	·973
V.	Mercury,	·391	1·930

Remarks on the foregoing Table.—1. Encke's mass of the Earth is $\frac{1}{3\,3\,3\,9\,3\,3\,1}$; that of the Earth, and Moon together, $\frac{1}{3\,3\,3\,4\,6\,6}$. It is scarcely necessary to observe that the former is to be used in determining the density, and the latter in estimating the diameter of the sphere of attraction. By applying the other masses in Table I, and the diameters in Table III, we obtain the densities in column third of the latter.

2. In each pair, *the densities of the members are to each other as the volumes; or, what is the same thing, as the square roots of the masses;* whence also it follows that the masses are to each other as the sixth powers of the diameters.

Thus if D, d = the respective diameters of the members of any pair;

Δ, δ = the densities;

M, m = the masses;

then $D^3 : d^3 :: \Delta : \delta$,

$\sqrt{M} : \sqrt{m} :: \Delta : \delta$,

and $M : m :: D^6 : d^6$.

3. The most recent authorities in regard to the diameters of the planets are *Hind's Solar System* and *Humboldt's Cosmos*, vol. iv, both published in 1852. The mean diameters of Mercury, the Earth, Mars, Jupiter, and Uranus are taken from the latter work, pp. 428, 511. Those of Venus, Saturn, and Neptune, which are known with less certainty than the diameters of the remaining members of the respective pairs to which they belong, are obtained by the preceding formula; *the resulting value in each instance falling between those of Humboldt and Hind.**

* Cosmos, vol. iv, pp. 428, 511, 517. Hind's Solar System, pp. 24, 103, 138. A remarkable error in regard to the diameters of Uranus and Neptune occurs in the latter work, pp. 120, 138. The apparent diameter of the former, reduced to the Earth's mean distance, is put for that of the latter, and *vice versa;* and hence it is erroneously concluded that the true diameter of Neptune is rather less than that of Uranus.

4. These analogies seem to indicate, (1) the existence of a planet within the orbit of Mercury; (2) a similarity in the original constitution of the members of each pair; and (3) an intimate mutual dependence or connection in their primitive condition.

5. If *one* trans-Neptunian planet should be hereafter discovered, the existence of a *second* would be rendered highly probable.

In the preceding article no special attention has been given to the objections of Professor Cherriman. Those, therefore, which have not been already discussed shall now be briefly considered.

Mr. C. first observes "that this law is not universal, being inapplicable in the case of the outermost planet (Neptune, so far as we know), and also of the Sun regarded as the innermost planet; in the former case, k being made to vanish by D becoming infinitely great; in the latter, by n vanishing." If the planets were formed from rings of vapor, was the primitive breadth of the outermost ring "infinitely great?" or does Neptune's sphere of attraction extend beyond the fixed stars and the Milky Way? Will Professor Cherriman also inform us why the "analogy between the periods of rotation of the PRIMARY PLANETS," should be rejected because of its inapplicability to the SUN?

Mr. C. has calculated the values of the rotation, constant for Venus, the Earth, and Saturn. These values he thinks "do not agree with sufficient exactness to establish the analogy;" he is, therefore, "compelled to reject" it, and "must agree with Professor Loomis," who "has most ably and strikingly pointed out" similar discrepancies. Unfortunately, however, while Professor Loomis's value of the rotation constant for Venus is *too small*, Professor Cherriman's is *too large*. The latter result was obtained by using Lagrange's mass of Mercury, $\frac{1}{2\,0\,2\,7\,1\,7\,4}$. That eminent astronomer observing, *previous to the discovery of Uranus*, that Jupiter is denser than Saturn but less dense than the Earth, concluded that the density varied inversely as the distance from the Sun. From this long since exploded hypothesis is derived the result which "compels" Mr. C. to withhold his assent from my analogy.*

Professor C.'s final difficulty, which, I have no doubt is entirely original, may be expressed as follows:—If one of the planets—the Earth for instance—should change its dimensions, and consequently its rotary velocity, the existing harmony between the periods of rotation *would be destroyed.* I beg leave to inquire of the ingenious objector whether the adoption of this mode of reasoning might not be fatal to other laws, as well as that of the planetary rotations? I assure him, however, that whenever we

* Professor C.'s value of k for the Earth is grossly erroneous.

shall find the Earth's time of rotation diminishing, I will cheerfully grant that my analogy can no longer be regarded as the expression of a "physical fact." But inasmuch as our planet's period of diurnal revolution *has not varied* the three hundredth part of a second during the last two thousand years, it may be as well to leave the discussion of this point to posterity.

Delaware College, July 5, 1852.

ART. XXV.—*On the Eruption of Mauna Loa, Hawaii, February,* 1852; by Rev. TITUS COAN.*

OLD Kilauea has been quite tame since I last wrote you. Changes have, however, taken place. The key stone of the great dome over Halemaumau (the lake) has parted, the top of the dome has fallen in, an orifice of about one hundred feet diameter has been opened, and an abyss of raging fire may be seen below at the depth of one hundred feet. Small lakes of fire have also broken out here and there in the crater, but the action has been partial and comparatively feeble. No light shines upon us from Kilauea, and we have no new terrors to record of Mother Pele at this point.

But we have other wonders among the fiery sisterhood.

At half-past 3 on the morning of the 17th ult., a small beacon-light was discovered on the summit of Mauna Loa. At first it appeared like a solitary star resting on the apex of the mountain. In a few moments its light increased and shone like a rising moon. Seamen keeping watch on deck in our port exclaimed, "What is that? The moon is rising in the *West!*" In fifteen minutes the problem was solved. A flood of fire burst out of the mountain, and soon began to flow in a brilliant current down its northern slope. It was from the same point, and it flowed in the same line, as the great eruption which I visited in March, 1843. In a short time, immense columns of burning lava shot up heavenward to the height of 300 or 400 feet, flooding the summit of the mountain with light, and gilding the firmament with its radiance. Streams of light came pouring down the mountain, flashing through our windows, and lighting up our apartments so that we could see to read large print. When we first awoke, so dazzling was the glare on our windows, that we supposed some building near us must be on fire; but as the light shone directly upon our couch and into our faces we soon perceived its cause. In two hours the molten stream had rolled, as we judged, about fifteen miles down the side of the mountain.

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* From a letter to Rev. CHESTER S. LYMAN, dated Hilo, March 5, 1852.

This eruption was one of terrible activity and surpassing splendor. But it was short. In about twenty-four hours all traces of it seemed to be extinguished.

At day break on the 20th we were again startled by a rapid eruption bursting out laterally on the side of the mountain facing Hilo, and about midway from the base to the summit of the mountain. This lateral crater was equally active with the one on the summit, and in a short time we perceived the molten river flowing from its orifice direct towards Hilo. The action became more and more fierce from hour to hour. Floods of lava poured out of the mountain's side, and the glowing river soon reached the woods at the base of the mountain—a distance of twenty miles.

Clouds of smoke ascended and hung like a vast canopy over the mountain, or rolled off upon the wings of the wind. These clouds assumed various hues—murky, blue, white, purple, or scarlet—as they were more or less illuminated from the fiery abyss below. Sometimes they resembled an *inverted* burning mountain with its apex pointing to the awful orifice over which it hung. Sometimes the glowing pillar would shoot up vertically for several degrees, and then, describing a graceful curve, sweep off horizontally, like the tail of a comet, farther than the eye could reach. The sable atmosphere of Hilo assumed a lurid appearance, aud the sun's rays fell upon us with a yellow, sickly light. Clouds of smoke careered over the ocean, carrying with them ashes, cinders, charred leaves, etc., which fell in showers upon the decks of ships approaching our coast. The light was seen more than a hundred miles at sea, and at times the purple tinge was so widely diffused as to appear like the whole firmament on fire. Ashes and capillary vitrifactions, called "Pele's hair," fell thick in our streets and upon the roofs of our houses. And this state of things still continues, for even now, while I write, the atmosphere is in the same sallow and dingy condition. Every object looks pale and sickly, showers of vitreous filaments are falling around us, and our children are gathering them.

As soon as this second eruption broke out, I determined to visit it. Dr. W. agreeing to accompany me, we procured four natives to carry our baggage, one of them, Kekai (Salt Sea), acting as guide. On Monday, the 23d of February, we all set off, and slept in the outskirts of the great forest which separates Hilo from the mountains. Our track was not the one I took in 1843, viz., the bed of a river. We attempted to penetrate the thicket at another point, our general course bearing southwest. In ancient days an Indian trail had been beaten through in this direction, but it was now entangled with jungle so that all traces of it were nearly obliterated. However, we plunged into the forest, with a long knife, hatchet and clubs, cut and beat our way at the rate of one and a fifth mile an hour. At night we slept in the bush, and

listened to the distant roar of the volcano. On Wednesday, the 25th, we gained a little eminence in the woods, from which we could see the lava stream which was now opposite us on our left, distant six miles. This fiery flood was now half way through the forest, and more than three-fourths of the way from the crater to the shore, sweeping all before it. Apprehending that it might reach the sea in a day or two, and that the ladies at the station might be alarmed, Dr. W. determined to return. Taking one of the natives, and leaving three with me, he retraced his steps, while I pushed on through jungle and bog and dell, beating every yard of my way out of this horrible thicket. On the 26th, we emerged from the forest, but plunged at once into a dense fog more dark than the thicket itself. Pushing up the mountain we encamped for the night on a rough, bushy ridge. A little before sunset the fog rolled off, and Mauna Kea and Mauna Loa both stood out in grand relief; the former robed in a fleecy mantle almost to its base, and the latter belching out floods of fire from its burning bowels. All night long we could see the glowing fires, and listen to the awful roar of this fearful crater.

We had now been out four nights, and were within twenty miles of the crater, with the long, brilliant river of fusion on our left, shining in a line of light down the side of the mountain till it entered the woods.

We left our mountain aerie early on the 27th, determined, if possible, to reach the seat of action on that day. Taking the pillar of fire and of cloud as our mark, and still having the great river of lava on our left, we pushed onward over a rough and almost impassable surface—the attraction increasing as the square of the distance decreased. Our intense interest mocked all obstacles. At noon we came upon the confines of a tract of naked scoria, so intolerably sharp and jagged that our baggagemen could not pass it. Here I ordered a halt; stationed the two carriers; gave an extra pair of strong shoes to my guide; gave him my wrapper and blanket; put a few crackers and boiled eggs into my pockets; took my compass and staff, and said to Mr. Salt Sea, (Kekai), "Now go ahead, and let us warm ourselves to-night by that fire yonder." Thus equipped we pressed up the mountain, over fields of lava of indescribable roughness; now mounting a ridge of sharp and vitreous scoria, when the fiery pillar stood full in view; and then plunging into some awful ravine or pit, from which we slowly emerged by crawling upon "all fours." But I soon found that my guide needed a leader. He was too slow. I therefore pressed ahead, leaving him to get on as best he could. At half-past 3 P. M. I reached the awful crater, and stood alone in the light of its fires. It was a moment of unutterable interest. I seemed to be standing in the presence and before the burning throne of the eternal God; and, while all other voices were

hushed, His alone spoke. I was 10,000 feet above the sea; in a vast solitude untrodden by the foot of man or beast; amidst a silence unbroken by any living voice, and surrounded by scenes of terrific desolation. Here I stood, almost blinded with the insufferable brightness; almost deafened with the startling clangor; almost petrified with the awful scene. The heat was so intense, that the crater could not be approached within forty or fifty yards on the windward side, and, probably, not within two miles on the leeward.

The eruption, as before stated, commenced on the very summit of the mountain, but it would seem that the lateral pressure of the emboweled lava was so great as to force itself out at a weak point in the side of the mountain; at the same time cracking and rending the mountain all the way down from the summit to the place of ejection. The mountain seemed to be siphunculated; the fountain of fusion being elevated some 2,000 or 3,000 feet above the lateral crater, and being pressed down an inclined subterranean tube, escaped through this valve with a force which threw its burning masses to the height of 400 or 500 feet. The eruption at first issued from a depression in the mountain, but a rim of scoria 200 feet in elevation had already been formed around the orifice in the form of a hollow truncated cone. This cone was about half a mile in circumference at its base, and the orifice at the top may be 300 feet in diameter. I approached as near as I could bear the heat, and stood amidst the ashes, cinders, scoria, slag and pumice, which were scattered wide and wildly around.

From the horrid throat of this cone vast and continuous jets of red-hot, and sometimes *white hot*, lava were being ejected with a noise which was almost deafening, and a force which threatened to rend the rocky ribs of the mountain, and to shiver its adamantine pillars. At times the sounds seemed subterranean—deep and infernal. First a rumbling, a muttering, a hissing, or deep premonitory surging. Then followed an awful explosion, like the roar of broadsides in a naval battle, or the quick discharge of park after park of artillery on the field of carnage. Sometimes the sound resembled that of ten thousand furnaces in full blast. Again, it was like the rattling of a regiment of musketry. Sometimes it was like the roar of the ocean along a rock-bound shore, and sometimes like the booming of distant thunder. The detonations were heard along the shores of Hilo.

The eruptions were not intermittent but continuous. Volumes of the fusion were constantly ascending and descending like a jet d'eau. The force which expelled those igneous columns from the orifice, shivered them into millions of fragments of unequal sizes, some of which would be rising, some falling, some shooting off laterally, others describing graceful curves; some moving

in tangents, and some falling back in vertical lines into the mouth of the crater. Every particle shone with the brilliancy of Sirius, and all kinds of geometrical figures were being formed and broken up. No tongue, no pen, no pencil, can portray the beauty, the grandeur, the terrible sublimity of the scene. To be appreciated it must be *felt.*

It was more than half an hour after my arrival at the crater before my guide came up. Night was approaching, and I had no defense against the piercing cold but in the wrapper and blanket committed to his care. I had began to fear that he had given up the pursuit, and, like my guide in 1843, left me to my own resources. I strained my eyes to examine every ridge and elevated spot on the track by which I approached the crater. At length his form rose to my view, slowly wending his way among the black and craggy masses of lava; and if ever my heart leaped for joy, or loved a man, or blessed the Lord, it was then. Throwing up his hands and opening his mouth like a crater, the old hero of the hills exclaimed, "*Kapaianaha!* KAPAIANAHA!!" *Wonderful!* WONDERFUL!! "*Kapaianaha loa na hana ake Akua!!*" *Most marvelous are the works of God!!*

Night coming on we now retired about a mile from the crater, and took up our position where we had a most perfect command of the whole scene. Here we halted, not indeed to sleep, for that were impossible, but to keep vigils—to listen to the awful roar and to watch the wonderful operations of this great furnace of Jehovah.

During the night the scene surpassed all power of description. Vast columns of lava, at a white heat, shot up continuously in the ever varying forms of pillars, pyramids, cones, towers, turrets, spires, minarets, etc. While the descending showers poured in one incessant cataract of fire upon the rim of the crater down its burning throat, and over the surrounding area—each falling avalanch containing matter enough to sink the proudest ship. A large fissure opening through the lower rim of the crater gave vent to the molten flood which constantly poured out of the orifice, and rolled down the mountain in a deep, broad river, at the rate, probably, of ten miles an hour. This fiery stream we could trace all the way down the mountain, until it was hidden from the eye by its windings in the forest—a distance of some thirty miles. The stream shone with great brilliancy in the night, and a long horizontal drapery of light hung over its whole course. But the great furnace on the mountain was the all-absorbing object. Hour after hour it sent out its thunders as the voice of Almighty God, and through the long night it loaded the atmosphere with its sulphurous breath, scattering far and wide its showers of fiery cinders, and throwing a terrible radiance over the dark and desolate mountain.

At day break on the 28th we retraced our steps down the rugged mountain, rejoined the baggagemen, broke up the camp, and, by a forced march, regained the confines of the woods before dark. This was on Saturday, and here we rested on the Sabbath. On Monday, by hard travelling for twelve hours, we reached Hilo, found all well, and felt rewarded an hundred fold for our toil of eight days.

March 6.—The fire has not yet reached the shore, and it may not. It is winding in the woods, filling our atmosphere with smoke, and sending down showers of ashes, charred leaves, etc.

The great furnace in the mountain is still in terrible blast. No decrease of activity, but rather an *increase*.

Old Kilauea is as dosy as ever. She has taken no interest in our exciting scenes, and seems to feel no sympathy with her fiery sister of the hills.

ART. XXVI.—*On the Rocks of Canada;* by Messrs. W. E. LOGAN and J. W. SALTER.*

1. *On the Age of the Copper-bearing Rocks of Lake Superior and Huron, and various facts relating to the Physical structure of Canada.* By W. E. LOGAN, F.R.S. & G.S., Director of the Geological Survey of Canada.

IN the present paper it is my purpose to place before the Association, in as a condensed a form as possible, one or two of the main features of the physical structure of Canada, ascertained in the progress of the Geological Survey now carried on in the country, under my direction, by the authority of the Provincial Government.

With the exception of the drift, the country is composed of rocks, none of which are newer than the carboniferous epoch. The general geographical distribution of these rocks, as far as ascertained and as connected with the physical structure of the bordering states of the American Union on the one hand, and the sister British provinces on the other, is represented on the map which is displayed to view.

One of the points to which it is my wish to draw attention is the age of the copper-bearing rocks of Lake Superior and Huron, as determined by the evidences collected on the Canadian survey; and another, the differences that exist in the structural condition of the western and eastern parts of the province.

The rocks on the north shore of Lake Superior consist of reddish granite and syenite, which in ascending order pass into micaceous and hornblendic gneiss and allied forms. These are succeeded by chloritic and partially talcose slates, which become interstratified with obscure conglomerates with a slaty base, and

* From the Proceedings of the British Association for 1851.

upon them rest unconformably bluish slates, with intermingled bands of chert and limestone towards the bottom, and a thick and extensive overflow of greenstone trap at the top. Reposing on these are white sandstones, which pass by an alternation of colors into red sandstones and conglomerates, often with jasper pebbles, and these are repeated after the occurrence of an uncertain amount of reddish limestone of an argillaceous quality. The sandstones and conglomerates become interstratified with amygdaloidal trap layers, and an enormous amount of volcanic overflow divided into beds crowns the summit. The sandstones are often argillaceous, and display ripple-mark and crack casts on their surfaces, while the concentric curves of flow sometimes characterize those of the trap. Innumerable dykes cut up the sedimentary and volcanic beds, and both the dykes and the overflows are almost universally marked by a transverse columnar structure. The thickness of the whole from the base of the blue slates cannot be less than 12,000 feet, and the whole formation is intersected by copper lodes of different characters in different places, which run in directions both with and transverse to the strike.

On the north shore of Lake Huron the granite is succeeded by a formation consisting of white, often vitreous sandstone or quartz-rock of great thickness, sometimes passing into a beautiful jasper conglomerate, and alternating with great beds of slate and bands of conglomerate with a slaty base, both being interstratified with thick masses of greenstone. A persistent band of limestone of about 150 feet in thickness and interstratified with thin cherty layers, occupies a place in the series, probably somewhere about the middle. The surfaces of the sandstone often exhibit ripple-marks, and the total thickness of all the members of the formation may be about 10,000 feet. Different intrusive rocks intersect those of stratification, and as related to one another, they display a succession of events in the history of the formation. There is of course a set of dykes—greenstone no doubt—cutting the sedimentary rocks and giving origin to the greenstone overflows. It is difficult, however, to identify these; but another set of greenstone dykes are seen cutting both the sedimentary and igneous strata; intrusive granite, sometimes occupying considerable areas, thrusts these antecedents aside, sending forth dykes of its own order, intersecting all and reaching to considerable distances from the nuclei; and then another set of greenstone dykes cuts through the intrusive granite, its dykes, and all that previous causes had placed. Evidences of disturbances and dislocations accompany all these successive intrusions, those connected with the granite being the most violent. But there is in addition another set of disturbances of still posterior date, and it is to these that is due the presence of those metalliferous veins which give the country its value as a mineral region.

In respect to the age of the Huron cupriferous formation, the evidence afforded by the facts collected by my friend and associate, Mr. Murray (published in our Report of Progress for 1847–48), on the Grand Manitoulin, La Cloche, Snake, Thessalon, Sulphur, and other islands, points ranging along a line of 90 miles out in front of the coast, is clear, satisfactory, and indisputably conclusive. On these islands, the Potsdam sandstone, the Trenton limestone, the Utica slates, and the Loraine shales, successive formations in the lowest fossiliferous group of North America, were each, in one place or another, found in exposures denuded of all vegetation, resting in unconformable repose, in a nearly horizontal position, upon the tilted beds and undulating surface of the quartz rock and its accompanying strata, filling up valleys, overtopping mountains, and concealing every vestige of dykes and copper veins; and it would appear that some of these mountains have required the accumulation of the whole thickness of the lowest three and part of the fourth fossiliferous deposit, equal to about 700 feet, to bury their summits.

The chief difference in the copper-bearing rocks of Lakes Huron and Superior seems to be the great amount of amygdaloidal trap present among the latter, and of white quartz rock or sandstone among the former. But on the Canadian side of Lake Superior there are considerable areas without amygdaloid, while white sandstones are present in others, as on the south side of Thunder Bay, though not in the same vast amount, or the same state of vitrification as those of Huron. But notwithstanding these differences, there are such strong points of resemblance in the interstratification of igneous rocks, and the general mineralized condition of the whole, as to render their proximate equivalence highly probable; and the conclusive evidence given of the age of the Huron would thus appear to settle that of the Lake Superior rocks in the position given to them by Dr. Houghton, the late State Geologist of Michigan, as beneath the lowest known American fossiliferous deposits; and in this sequence those of Lake Huron, if not those of Superior, would appear to be contemporaneous with the Cambrian series of the British Isles.

The eastern limit of this formation on Lake Huron is in the vicinity of Colling's Inlet, opposite the eastern extremity of the great Manitoulin Island, whence it gradually recedes inland, taking a northeastern course; and farther down the St. Lawrence and its lakes, the Lower Silurian appear to rest upon gneissoid rocks without the intervention of the Cambrian.

If a line be drawn on the map in continuation of the Hudson River and Lake Champlain valleys to the vicinity of Portneuf, about thirty miles above Quebec, and thence in a northeastward direction, it will divide the country into two areas, which, though nearly resembling one another in the general formations of which

they are composed, yet present important differences in their structural condition. Each area belongs to a great trough of fossiliferous strata resting in Canada, with the exception of the supporting Cambrian formation of Lakes Huron and Superior, on gneissoid rocks, and containing coal measures in the centre, and the conditions in which the two areas differ, are the general quiescence and conformable sequence of the formations from the base of the Lower Silurian upwards in the western, and the violent contortions and unconformable relations of those in the eastern. The coal measures of the eastern area are those of Rhode Island, and in a metamorphic state of Massachusetts, and those of Nova Scotia and New Brunswick. None of the productive part of the New Brunswick coal-measures reaches Canada, but there comes out from beneath it, on the Canada side of the Bay Chaleur, 3,000 feet of carboniferous red sandstones and conglomerates. These are succeeded by 7,000 feet of Devonian sandstones, which rest upon 2,000 feet of Upper Silurian rocks consisting of limestones and slates. The base of the Upper Silurian group has been traced a distance of about 700 miles from Gaspé on the Gulf of St. Lawrence, first to Memphramagog Lake in Canada, thence to Halifax on the southern limit of Vermont, and further into Massachusetts, keeping in its outcrop at a variable distance from the coal. In the interval, between the Upper Silurian and the carboniferious formations, there can be little doubt the Devonian sandstones will display a conspicuous figure in the eastern area, as they are known to be still 2,500 feet thick in the eastern portion of the western area, in which they do not die away until reaching the banks of the Mississippi. In the eastern area the Lower Silurian strata sweep round the Upper, occupying a zone of between 40 and 50 miles broad, and the lowest rock common to both, connecting the troughs on the anticlinal, in the valley of Lake Champlain, is the Trenton limestone.

On the northwestern side of the western area the formations are generally in a flat and quiescent condition from Lake Superior to Pennsylvania, and they succeed one another, without any observed want of conformity, from the base of the Lower Silurian to the summit of the carboniferous. But it has been shown by Professor Rogers, that proceeding from northwest to southeast there occurs in the State of Pennsylvania a set of successive parallel undulations which increase in intensity in the direction mentioned, and on the southeast side of the Appalachian coalfield are sufficiently violent to produce overturn dips in all the formations together, the coal inclusive. These plications with their overturn dips thus form the southeastern rim of the western area, and are distinctly traceable by the Appalachian chain through Vermont into Canada, and through Canada to the Gulf of St. Lawrence; in this part constituting the northwestern rim of the

eastern area. But while in the western division there is no want of conformity from the Lower Silurian rocks to the carboniferous, and the plications there appear to be of a date subsequent to the carboniferous deposit, in the eastern, there are evidences of a want of conformity between the Upper and Lower Silurian formations, and though the folds in the former do not seem quite so violent, they are in parallel directions with those in the latter. There is another and a greater want of conformity between the Devonian rocks and the carboniferous. A large portion of the carboniferous deposit of New Brunswick shows but very moderate dips, and on the shores of Bay Chaleur it lies in a quiescent condition on the tilted edges of the lower formations, sometimes resting on one and sometimes on another. Its north-western outcrop however, or rather, I should say, the longitudinal axis of the whole coal-field from New Brunswick to Newfoundland, has a parallelism with the folds of the inferior rocks, and there are several parallel undulations in nearly the same direction on the south side of the carboniferous deposit.

The conclusion to be drawn from these facts appears to be, that some cause producing folds in the stratification in one general direction has been in operation from at least the cessation of the Lower Silurian epoch to the termination of the carboniferous; and it only requires the inspection of a map of Atlantic America to observe how the features of its physical geography, displayed in the configuration of its coast, in its valleys of undulation and those of transverse fracture, are almost entirely dependent on the results of this cause.

The fossiliferous rocks of both these divisions, with the exception of that part supported by the Cambrian formations of Lakes Superior and Huron, rest, along the valleys of the St. Lawrence and the Ottawa, upon a series consisting of micaceous and hornblendic gneiss interstratified towards the south with great bands of crystalline limestone, sometimes highly charged with magnesia and associated with vast masses of magnetic iron ore, but without calcareous beds on the north. These rocks constitute a part of the low granitic ridge, which to the westward has been traced by Sir J. Richardson as extending with a northwesterly curve to the Arctic Ocean.

The Canadian rocks on the north side of this granitic ridge, as displayed toward the head of Lake Temiscamang, consist, in ascending order, of chloritic slates and conglomerates with a slaty matrix; the volume of these is probably not less and may be much more than 1,000 feet. On them rests a set of massive pale greenish-white or sea-green sandstones, the total amount of which, as determined by the height of hills which they compose in nearly horizontal layers, is between 400 and 500 feet. These are succeeded by about 300 feet of buff and whitish fossiliferous lime-

stones, the lowest bed of which is composed of a collection of great boulders and blocks of sandstone, some of them nine feet in diameter, that were lying immediately on the strata from which they were derived when they became covered up, and in which great cracks and worn fissures are filled with the calcareous deposit that envelops the whole. The sandstones being without discovered fossils, it is not easy to determine their age; but the limestones by their organic contents are distinctly shown to belong to the Upper Silurian epoch. The Lower Silurian deposits, unless the non-fossiliferous sandstones be a member of the group, appear to be wholly wanting in the locality, and as all the forms brought from other localities on the north side of the granite ridge by Bigsby, Richardson and others, are, I believe, referable to Upper Silurian types, it appears not improbable that the absence of the Lower Silurian rocks may spread over an extensive area, and the south side of the ridge indicate an ancient limit to a Lower Silurian sea.

The nearest locality of the well-defined forms which inhabited this sea is at the island of Allumette, about 200 miles southward from the Upper Silurian rocks of Lake Temiscamang; there is, however, a patch of the same lower formation which is only about 100 miles southward from them, but in it the fossils are obscure. Instead of giving any remarks of my own on the fossils of the two sides of the granitic ridge, I shall append to my paper a note, which my friend Mr. Salter, of the Geological Survey of the United Kingdom, has been so kind as to make on them after a careful inspection, only stating that the specimens which have been examined are but a small part of an important collection, chiefly from the eastern of the two divisions that have been alluded to, brought from Canada for comparison, and that twice as many specimens as have been brought remain in the province from other parts, while great additions, it is hoped, will annually be made to them.

2. *Note on the Fossils above mentioned, from the Ottawa River.* By J. W. Salter, F.G.S., A.L.S.

Lower Silurian.—The fossils from the southeast end of Allumette Islands, on the Ottawa River, are the only Lower Silurian fossils yet examined of Mr. Logan's large collections, and they bear out well the opinion he has expressed, that in some parts of Canada but one calcareous group can be distinguished between the Potsdam sandstone below, and the Hudson River group above, agreeing in the main with the celebrated "Trenton limestone" of New York, but possessing also many of the fossils characteristic of the lower limestones which in that country have received separate names.

For instance, one of the most abundant fossils is a species of *Scalites* (*Euomphalus uniangulatus*), described as a fossil of the calciferous sand-rock by Hall. The corals, again, *Stromatocerium rugosum*, *Columnaria alveolata*, which are very abundant, are those of the Bird's-eye and Black River limestones. The former of these corals, too, is usually found investing (after the manner of a sponge) a large and fine species of *Maclurea*, a genus of gasteropods which in New York does not mount above the "Chazy" or lowest limestone, and is there abundant. Hall, indeed, expressly mentions that the *Stromatocerium* occurs in beds above those which contain the *Maclurea*. In this case, however, the parasitic zoophyte has generally selected this fine and new shell, to which I propose giving the name of its discoverer. It is well distinguished from *M. magna*, by the much more rapid increase in diameter of its whorls and its minute umbilicus. It is possessed, moreover, of a most peculiar operculum, which will at once establish the right of *Maclurea* to rank as a distinct genus, being furnished within with a broad and strong bony process for the muscular attachment, and being itself very strong and massive. Prof. Forbes has undertaken to compare this peculiar operculum with that of some rare living gasteropods of far inferior size, so that more need not be said of it at present.

The *Stromatocerium* affects also a small and new species of *Scalites* allied to the one above mentioned, and frequently covers all but the mouth, so as to mask the form of the shell completely.

But it is with the Trenton limestone that the greater number of species agrees; and while a large portion of them, especially the gasteropods, appear to be undescribed in Hall's work, still the analogies are very evident. A list of ten or more *Murchisoniæ* or *Pleurotomariæ* affords one, *M. ventricosa*, characteristic of the Bird's-eye limestone; two common in the Trenton limestone, *M. bicincta* and *M. gracilis* (very abundant species), and *M. bellicincta*, Hall, a large *Turritella*-like form; the rest seem to be new; and some of them are remarkable for the tendency of the whorls to separate and become what may be called vagrant, as happens in some accidental varieties of the common snail. The shells are tolerably thick and strong.

Some smooth shells, exactly like the *Euomphali* of the carboniferous limestone, and several roughly sculptured *Turbines* or shells of apparently allied genera, occur; and one exceedingly elegant, with close thread-like lines of growth, is very common. *Holopea* of Hall, an ill-defined genus, offers one or two species of the typical form, and one closely allied to *H. bilix* of the Western States. There are three species of *Scalites*, a genus with the mouth notched like *Pleurotomaria*, but destitute of a spiral band; one is the small species so commonly encrusted over; a second, of which we have but a single specimen, is muricated with spines,

like a *Delphinula;* the third is the very common *S.* (*Euomphalus*) *uniangulatus* above mentioned, which also, but rarely, shows a tendency to become spinose. There are also two or three species of the genus *Raphistoma*, which appears to be only a discoid form of *Scalites*. We have a *Turritella?* spirally ribbed, and undistinguishable in general form from living species. But the most abundant and characteristic shell is the *Maclurea*, fragments of which, with scattered opercula, occur on almost every surface.

Among bivalve shells, which chiefly belong to the *Arcacidæ*, a very interesting new genus has rewarded examination. It was found that two species resembling *Nucula* in every general character, differed from it importantly by having no internal ligament, but a very manifest exterior one; one of these species measures three inches across, and from the general analogy of several accompanying species it is believed that this form will be found common in the Silurian rocks, and will include many species now referred to *Nucula*. It might be called *Ctenodonta*. Of the same family also, a *Lyrodesma* (a genus with radiating teeth beneath the beak and synonymous with *Actinodonta*, Phillips) is closely allied to a Trenton limestone species. There is a new genus, probably belonging to the *Arcacidæ*, but only possessing two or three anterior teeth; but the collection does not include any *Aviculæ*, or indeed any other of the usual Silurian genera of this order, and of the seven or eight lamellibranchiate shells none appear quite identical with those from New York; but, as might be expected, the common *Brachiopoda* of this locality are those most abundant also in the Trenton limestone. *Orthis tricenaria*, Conrad, swarms here, as does also *Leptæna filitexta*, Hall, a shell very like the common *L. alternata* of the Trenton limestone, but reversed as to the convexity of the respective valves. But the latter shell, so abundant in New York, does not occur here at all. *Atrypa hemiplicata*, Hall, and *A. increbrescens* are tolerably frequent; and there are two or three other species of *Orthis*, and some small plaited and smooth *Terebratulæ*, which require further examination.

The *Bellerophons*, two of which are probably identical with New York species, are those of the lowest or chazy limestone, namely, *B.* (*Bucania*) *sulcatina*, Emmons, and *B. rotundata*, Hall. The group to which these two belong is that of which the English *B. dilatatus* is a familiar type, the whorls scarcely enveloping each other, and the mouth wide and trumpet-shaped. There is, however, a true *Bellerophon* so like *B. obtectus*, Phill., from the Ludlow rocks of Pembrokeshire, that, but for its treble size, it might be taken for it.

Perhaps one of the most interesting of the mollusks is a large *Cleodora*, quite new to America, and not yet described as such from Britain. On attentively comparing the American, Irish and

North Welsh specimens of this fine shell, which measures two inches across, I can find only trivial variations. It does not require a new specific name, having been figured from an imperfect specimen, as *Atrypa transversa*, by Portlock. It is interesting to find this species (which of course, as a Pteropod, had ready means of migration) in the two countries. There are but few other species identical with those of Great Britain, but I think I recognise *Turbo trochleatus*, and perhaps *T. triforquatus*, M'Coy, as common to the two regions.

Of the Cephalopoda, the remarkable two-edged *Orthoceras*, called *Gonioceras anceps* by Hall, is a Black River limestone species. *Cyrtoceras* is common, both smooth and ornamented; *C. annulatum* and *C. lamellosum*, the same with those of Trenton; *Orthoceras arcuo-liratum*, *bilineatum*, and *laqueatum*, Hall, are Trenton limestone species; and lastly, there are two species of *Ormoceras*, Stokes, the larger of which is in all probability *O. tenuifilum*, Hall, a species both of the Black River and Trenton beds.

Schizocrinus nodosus, Hall, of the Trenton limestone, is the common crinoid; its stems are very characteristic.

Among the corals, one or two species of *Streptolasma*, apparently the same as those of New York, and the branched varieties of *Favosites lycoperdon*, accompany those before mentioned; and we may here notice the *Receptaculites*, already described by Hall, but not I think identical with *R. Neptuni* of Europe. The fine series brought home by Mr. Logan shows all the structural characters;—the circular expanded form and cup-like centre,—the surface composed of rhomboidal plates, which cohere by lateral processes, and which are the flattened ends of separate and equidistant columns. Unfortunately the entire structure is replaced by cycloidal silex, but perhaps it will, by careful polishing, enable us to see if it be really a coral, somewhat of the character of the *Tubiporidæ*.

To crown all these are slabs full of the large *Asaphus* (*Isotelus*) *gigas*, the characteristic trilobite of the Trenton rocks.

Upper Silurian Rocks.—Ascending the Ottawa to the head of Lake Temiscamang and so crossing the granitic axis of Canada, the first fossiliferous rock that presents itself is of a totally different character to that last described, as stated by Mr. Logan in his Report of Progress for 1845.

This limestone is weathered like the last; its siliceous fossils also stand out in bold relief; and one of the most common is the characteristic crinoid of the Trenton limestone, *Schizocrinus nodosus*, at least I believe I am correct in this reference. But along with this are abundance of *Favosites gothlandica*, *Stromatopora striatella*, *Cyathophyllum*, a *Heliolites* (*Porites*), with small tubes; *Syringopora* (*Harmodites*) with *Halysites catenulatus*

(*Catenipora escharoides*), and *Strombodes striatus*, Milne Edwards, fossils characteristic of the *Niagara* and *Onondaga* limestones, and in America never found in the lower rocks; with these occur *Atrypa reticularis* in plenty, a *Terebratula* with three raised plaits, and very rarely a *Leptæna* or *Strophomena*. One or two spiral shells recall the shapes of some of Hall's species of *Holopea*, but are too imperfect for identification; and there is a long spiral shell, like *Murchisonia gracilis*. *Encrinurus punctatus* is the only trilobite.

The most striking shell, perhaps, is a species of *Ormoceras*, the short broad siphuncles of which are well preserved, while the shell has decayed, and these so much resemble those figured by Dr. Bigsby and Mr. Stokes in the Geological Transactions, second series, vol. i, pl. 30, figs. 4, 5, 6, 7, that we think there can be no doubt of their identity. And it is very interesting, as bearing on the question of age, that these were found at Drummond Island, the only limestones of which are Upper Silurian.

Indeed the whole aspect of this collection, small as it is, is as strikingly Upper Silurian as that of the former one was Lower Silurian. The preponderance of the *Catenipora*, *Favosites* and *Stromatopora*, &c., is characteristic of the higher rocks, and they are associated with *Pentamerus oblongus* (the characteristic fossil of the Clinton group, which may be regarded as the base of the upper division), and this shell in America is far more limited in its vertical range than it is in Britain.

ART. XXVII.—*The Inverted Microscope—a new form of Microscope; with the Description of a New Eye-piece Micrometer, and a New Form of Goniometer for Measuring the Angles of Crystals under the Microscope;* by J. LAWRENCE SMITH, M.D., Professor of Chemistry in the University of Louisiana.

THE instrument forming the subject of this article, was invented by me in the summer of 1850, and first brought to the notice of the *Société de Biologie* of Paris in the month of September of the same year; and, with additional improvements in the micrometer movement, was laid before the American Scientific Association in 1851. Besides the mention made of this instrument in the minutes of the proceedings of those scientific bodies, no account of it has been published, giving a full detail of the objects sought after and effected by this new form of Microscope: and this I now hasten to do, in justice to myself, since seeing in the last edition of Quekett's work on the Microscope, a short description of this instrument under the title of Nachet's Chemical Microscope. How it is that my name has been entirely omitted in connection with it, is a mystery to me; it must have arisen

through Mr. Nachet's neglect to mention who the inventor of it was while exhibiting it at the World's Fair in London last year, or through the forgetfulness of Mr. Quekett, after being informed on the subject. This omission is still more glaring, from the fact that the instrument as then exhibited, with one or two very unimportant modifications, is the same in all its mechanical details as was constructed for me, from my plans, by Mr. Nachet, of Paris, and used in the laboratory of Messrs. Wurtz and Verdiel.

I am sorry to be obliged to preface the description of the Microscope with this reclamation; but after considerable experience, I feel that the instrument is an important one for general as well as chemical purposes, and that it will in time be considered a decided advancement in the construction of microscopes; with these views in the matter, I am unwilling to yield what little credit might be due to the inventor of it.

The great development made in microscopic research, during the last twenty or thirty years, is due in great part to improvements in the construction of achromatic object-glasses; still, the mechanical arrangements of the instrument have contributed their share to facilitate observation, and diminish the fatigue dependent upon this character of research. In fact, observers have not hesitated to make use of different descriptions of mounting in their varied field of research; and now, we have instruments for general purposes, but the construction of which is imperfectly adapted to certain special researches; as, for instance, the dissection of animal tissues. This last circumstance has given rise to the invention of various forms of dissecting microscopes, such as the Pancreatic Microscope of Oberhauser, and more recently the simple and better instrument for arriving at the same end constructed by Nachet, of Paris.

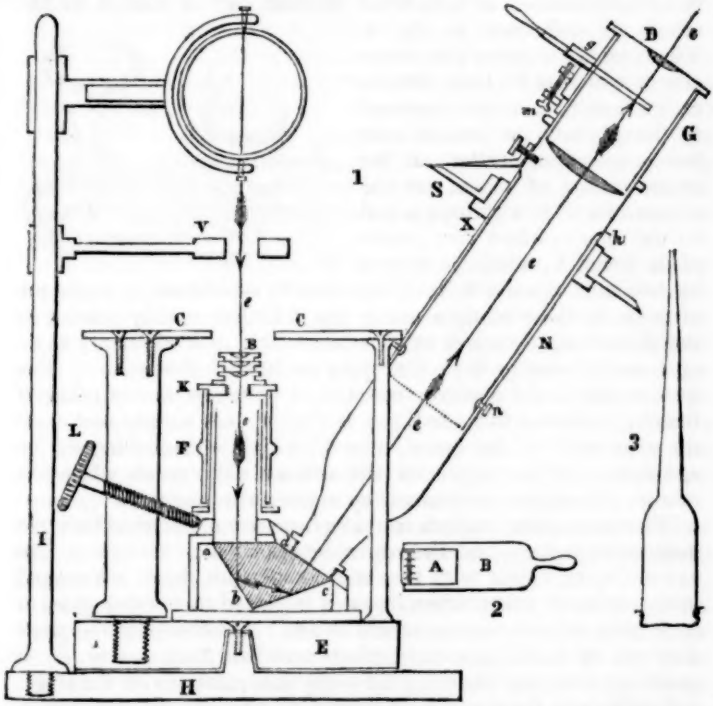
These remarks are made to show how the use of the microscope might be extended by paying proper attention to its mechanical arrangements, and it is from this cause I have been led to seek out a form of instrument, by means of which micro-chemical research might be facilitated and enlarged. The instrument about to be described is calculated to produce these results.

The great obstacle to chemical research beneath the microscope, are two-fold; first, the necessity of manipulating in the limited space between the object-glass and the stage; and, secondly, the exposure of the most essential parts of the instrument to the vapors emanating from the re-agents employed, and the condensation of vapor on the under surface of the object-glass thereby obscuring the view. A less important obstacle is the impossibility of heating a liquid or other substance while beneath the microscope.

The only way by which these difficulties can be surmounted, is to place the object-glass beneath the stage, and the object above it, with an optical arrangement of such a nature as to permit observation. It was with this in view, that M. Chevalier made a

chemical support to go with his general instrument, but those familiar with it know how awkward it is for manipulation, although exceedingly ingenious, and, doubtless, as perfect as could be for attaching to his instrument. Feeling then the want of something more effective, I was led to the construction of the Inverted Microscope, entirely with reference to its chemical uses; other purposes to which it might be applied being of secondary consideration; but I would here remark, that since its completion, its value even in this latter respect yields to no other form of instrument, and has induced me to change its original designation of Chemical Microscope to that of Inverted Microscope, as the former name might mislead as to the extent of its uses.

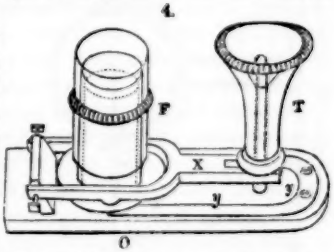
It was important for the arrangement in question, so to have the relative position of the stage and eye-piece, that the eye, while on a level with the latter, could readily see the former and guide the required manipulations.



Without entering into any detail of the steps taken in the construction of the instrument, I will at once proceed to a description of it, that will be readily understood by referring to the figure. The most important part is a four sided prism, with the

angles *a*, *b*, *c*, *d*, respectively 55°, 107½°, 52½°, 145°, the angles being of such dimensions, that a ray of light passing into the prism in the directions shown by the arrows, and perpendicular to the surface *a d*, after undergoing total reflection from the inner surfaces *a b* and *b c* (on both of which the light strikes at an angle much less than forty-five degrees) will pass out perpendicular to the surface *c d*. If the line *c* be followed, it will be readily seen how a ray of light passing through the object-glass B, descends into the prism, and passes out of it upwards through the eye-glass D, the tube of which is inclined to the perpendicular 35°. The other parts of the instrument are understood by simply looking at the figure. E is a heavy support that revolves on another support H, which carries a column I, on which are placed the mirror, diaphragm, &c. The prism used has each side nearly an inch in length, and little less in width, which is about the most convenient size. The arrangement for adjusting the focal distances is somewhat peculiar, and is readily understood by reference to fig. 4. There are three tubes (the outer one of which is F) that slide on each other, the inner is fastened to the plate O, the second tube has a projecting collar, on the under surface of which rest the extremities of two springs *y*, and on the upper surface two points of the lever X, which is moved by means of the screw T. The plate O is fastened on to the top of prism by the binding screw L (fig. 1), that readily allows of the plate being detached at pleasure, which it is necessary to do at times in order to wipe the upper surface of the prism. The way in which the observer operates, is to screw one or other of the object-glasses to a small cap K (fig. 4) that simply rest on to the upper end of the outer tube F, which is readily moved up and down by the finger for the coarser adjustment, while the minute adjustment is obtained by moving the screw T.

4.



This description suffices to make it clearly understood how the instrument is used, and the conveniences arising therefrom. In examining an object with this microscope, the object is arranged in the ordinary way; when liquid it is placed in a watch glass or such glass cells as are convenient to use. In employing re-agents they can be added, and their effects watched immediately, for it is readily seen how the eye guides the manipulations on the stage, and looks into the instrument almost at one and the same time; a circumstance that facilitates and renders highly satisfactory all such operations, as nearly two years experience has convinced me.

With this arrangement we need not hesitate to employ hydrofluoric acid among our re-agents, as Prof. Bailey has already done, for the purpose of settling in a most ingenious manner, that the markings on certain microscopic siliceous animalculæ are elevations and not depressions, as they appear last under the action of this acid.

On the supporting ring V, are placed the diaphragms, palarascope, achromatic condenser, &c. I have also arranged a small ring of ivory, through the edge of which two wires pass that can be made the poles of a galvanic battery, and thereby subject anything to an electric action while on the microscope. The extremities of the wires may be united with a spiral of small platinum wire, which would become heated by the passage of the electricity, and in this state can be brought immediately over the object under examination.

There is another and very simple method which I have adopted for heating or evaporating liquids while on the stage of the microscope; it consists of a thin plate of brass about five inches long and an inch wide, with a hole in the centre. About an inch and a half each side of the hole, there are two screws projecting about the tenth of an inch. When required it is placed on the stage with the projecting screws downwards, that prevent the plate from touching the stage, and the part of the plate projecting beyond the stage is heated by a small lamp; the heat is readily propagated along the plate, and imparted to the glass that may be placed along it.

In using this instrument for chemical purposes, it is very necessary to be able to apply the re-agents conveniently, and for this purpose I place such of them as are used in two ounce phials, in the neck of which there is a small drop tube as represented in fig. 3, over the top of which is stretched a piece of sheet india-rubber, and by pressing and relaxing it, the liquid is drawn in, and by pressing the same the smallest possible quantity can be discharged on the object subject to examination. The tube also serves as a stopper to the phial, for the length of the capillary extremity is such that it reaches nearly to the bottom.

The acids and ammonia used are always diluted to about one half their ordinary strength, to prevent any unnecessary disengagement of vapors.

A moveable stage under many circumstances is very convenient, and I have adopted one of a very simple character, and quite equal to any of those where the motion is produced by screws or pinions. It is a circular plate of metal or glass, about three-fourths of an inch less in diameter than the fixed stage of the instrument, and an eight of an inch thick, with a hole in the centre of nearly an inch diameter. This is laid in the stage of the instrument, the glass sustaining the object placed on it, and when

required the former is moved by the fingers, which can readily impart to it the most delicate motion, as they are in part supported by the edge of the fixed stage. For this suggestion I am indebted to Prof. Riddell, and both he and myself, after much experience, feel convinced of its usefulness.

In observing with high powers, as the object-glass is beneath the glass supporting the object, and as this glass is usually of a certain thickness, we have to change our method of observation —for all powers resorted to in chemical examination this difficulty never occurs, and in using high powers it is easily obviated. Where the object is already mounted and dry, the thin glass can be readily turned downwards; but where it is moist, as, for instance, in examining fresh *Desmidiæ* and *Diatomaciæ*, the following plan is resorted to, namely to use a cell made of a thin piece of brass or glass, perforated with a hole about a half an inch in diameter, it is best to give the hole a considerable bevel in one direction, as it facilitates the cleaning of it, over the small end of the hole a piece of thin glass is stuck with balsam or other cement. When used the object to be examined is placed within, and a cover of thin glass placed above. When brass is used to make the cell, it may be as thin as the twentieth of an inch, and I have two such in my possession, made for me by Prof. Riddell, and they are certainly the most convenient things of the kind I have ever used. And here I may remark that for all observation with high powers, the Inverted Microscope is decidedly superior to the ordinary forms of mounting, for in the latter case, when an object-glass of a $\frac{1}{12}$th or $\frac{1}{16}$th inch focus is used, the focus is too short to admit of the use of cells, whereas in the inverted form, as the object is looked at from beneath, the cell may be as thick as one pleases. Another thing that I have discovered connected with this class of observations, is that the *Diatomaceæ* and *Desmidiæ* can be observed to much greater advantage from beneath than from above, for reasons that will be obvious to persons accustomed to observe these classes of objects.

Another advantage possessed by this instrument calculated to extend its use for general purposes, is its great capacity for every variety of illumination, without sacrificing the ease and freedom from fatigue belonging to the use of this form of Microscope; for when placed on a table, rather higher than the one commonly used, and a foot or two from the edge, the observer can recline on his arms, and observe for hours without the slightest sensation of fatigue.*

* As Prof. Riddell, of the Medical Department of the University of Louisiana, has been using my microscope for general purposes for more than a year, I requested of him his opinion as to its advantages, which is expressed in the following letter:

Prof. J. Lawrence Smith:—*Dear Sir*,—In reply to your note respecting your Inverted Microscope, I have to say that having formerly been in the habit of using the mountings of Pritchard, Dollard, Raspail, Chevalier and Nachet, and having the

Many little additional conveniences will suggest themselves to almost all microscopists who may use this instrument, but the great principle belonging to it is what I desire to make public, and any other adjuncts that might be described are such as belong to all forms of microscope.

New form of Eye-piece Micrometer for Measuring Objects under the Microscope.—Facility of measuring objects under the microscope is a great desideratum; and for that reason I now make known what I have been using for this purpose for upward of two years, as it furnishes all that can be desired. The eye-piece micrometer ordinarily in use, consists of a glass with divisions drawn in it, contained in a special eye-piece adapted for its use; and whenever the measurement of an object is required, we replace the eye-piece used by the micrometer eye-piece, and move the object on the stage, so that its image falls on the marking of the micrometer. With all its advantages this form has many inconveniences, among which I will mention the necessity of using an eye-piece which is not always the best for examination, the constant interposition of the micrometer in the field of observation, and the necessity of moving the object so as to superpose its image on the micrometer.

The eye-piece micrometer of Mr. George Jackson, described in Quekett's work on the Microscope, is an improvement on the one just mentioned, but does not do away with all the objections.

By the present arrangement, the micrometer can be used with any eye-piece, it can be withdrawn at pleasure and placed over the image of the object without regard to its position in the field; for this purpose the tube of the microscope is in two parts, G and N (fig. 2), the former has a collar *h*, and projects a couple of inches into N, turns freely in it, and is retained by a small screw *n* passing through N and playing on a grove in G. On the upper part of G there is a small rectangular opening in a little mechanical arrangement as seen in *m*. The various eye-pieces are so mounted that when placed in the tube G, the planes of their foci

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past year constantly used my best lenses (Spencer's make) in the Inverted Microscope, I am fully satisfied of the practical superiority of the latter for general purposes. With it, observation can be made with more ease and comfort, the light admits of more convenient and efficient management, chemical re-agents can be applied to the object with the greatest facility, without endangering the instrument, and the slides can be moved or changed with the utmost facility, and with perfect safety to the object-glass and the slides themselves. The instrument is so firm as to manifest no vibration with the highest powers, and admits of the attachment of every collateral appliance. I shall never willingly return to the habitual use of any other known form of microscope, especially with high powers. The excellency of your form of microscope depends on having a good reflecting prism below the object-glass; the one used by me, made by Oberhauser of Paris, seems to be perfection itself, and seems neither to absorb or distort the luminous rays in the slightest degree. Respectfully yours, J. L. Riddell.

correspond with the opening at *g*, and at the same time there is an opening in their mounting which is made to come opposite to that of *g*. The micrometer is seen in fig. 2, and consists of a brass mounting B with a small plate of glass A, having near the outer edge a fine graduate scale (the one used is ten millimetres divided in one hnndred parts) made in the direction of the breadth and not of the length of the micrometer, which little circumstance is of vast importance: for made as it is, it can sweep the field of the microscope; whereas were it graduated longitudinally, it would simply move in the radii of the field, and therefore could not be brought on the object in many of its positions.

The manner of using the micrometer can be understood in a few words. In examining with any eye-piece, if it be required to measure an object. The micrometer B is introduced into the opening *g*, and if not seen distinctly, by turning the screw *p* it is readily adjusted, and by pushing it backwards and forwards, or turning the tube D, the graduated scale can be readily brought over the image of the object, either longitudinally or otherwise; and knowing the value of each division, the dimensions of the object is readily made out. The manner of ascertaining the value of these divisions is learnt in almost every work on the microscope. This method of mine is now adopted by M. Nachet, of Paris, in the construction of his large microscope.

A new form of Goniometer for Measuring Angles of Crystals under the Microscope.—The measurement of the angles of crystals beneath the microscope is at best a very imperfect operation, for we can only measure plane angles, the angles between the faces not being measurable; yet, imperfect as it is, it is an important adjunct in certain researches, as may be seen by referring to the following, which is an extract from Lehmann's work on Physiological Chemistry, where he speaks of detecting a minute quantity of urea in albuminous fluids.

"If the residue of the fluid, from which the coagulated matters have been filtered, be extracted with cold alcohol, and the solution rapidly evaporated, so as to cause the chlorid of sodium (taken up by the cold alcohol) to separate as much as possible in crystals, or then bringing a drop of the matter-liquid in contact with nitric acid under the microscope, we shall observe the commencement of the formation of rhombic octahedra, and the hexagonal tablets, in which, if the investigation is to be unquestionable the acute angles ($=82°$) must be always measured. After the determination of the nitrate, we may also obtain the oxalate, and submit it to microscopic examination. *A good crystalline determination yields the same certainty as an elementary analysis, which, in these cases, would never or extremely seldom be possible.*"

Two of the best goniometers used for this purpose are those of Ross and Leesom, the latter being doubtless the best, and based on the use of the double refracting spar. After trial, however, I find it neither as accurate nor as economical in its construction as the following :—

Around the tube N, fig. 1, there is a collar X fastened to it; on the collar there is a graduated circle S, about three inches in diameter, turning freely on X. On the tube G a small index *t* is fastened. These are all the additional parts necessary, as the micrometer just described is used to aid in the measurement, which is accomplished as follows: The angle of the crystal to be measured is brought as near the centre of the field as the eye can readily judge of, (a little deviation will not sensibly affect the measurement); the micrometer is then introduced in the opening *g*, and turned about until the lines are parallel to one side of the angle, or until one of the long marks correspond with that side; this done, without disturbing the tube G, the graduated circle S is turned, until the index *t* points to zero. Now look again into the instrument, and turn G until the markings on the micrometer are parallel with the other side of the angle; read the number of degrees on the circle, and this will be the angle or its compliment. It frequently happens that the micrometer has to be moved in or out to make the lines on it accord with the second side, but as this motion is altogether a parallel one, the accuracy of the measurement is not at all effected. The simplicity of the mechanical arrangement is readily seen; the same advantage in using the micrometer with every eye-piece belongs to the goniometer.

ART. XXVIII.—*Abstract of a Meteorological Journal, kept at Beloit College, Beloit, Wis., for the year* 1851. Lat. 42° 30′ 23″ N., long. 12° 03′ 20″ W. from Washington: elevation above Lake Michigan, 172 feet—above the ocean, 750 feet; by S. P. LATHROP, M.D., Professor of Chemistry and Natural History.

MONTH.	BAROMETER.			THERMOMETER.			Clearness of sky.	Prevailing winds.	Inches rain & melted snow.
	Max.	Min.	Mean.	Max.	Min.	Mean.			
January,	29·89	28·68	28·70	56	−19	24·72	5·04	N.W. & S.	2·16
February,	29·83	28·95	29·37	55	0	33·57	5·20	S. & N.	3·43
March,	29·58	29·10	29·29	76	8	39·00	6·95	S. & N.	·55
April,	29·85	28·85	29·28	76	24	43·80	6·37	N. W. & N.	2·35
May,	29·61	28·85	29·32	84	23	57·30	5·50	S.E. & N.W.	15·46
June,	29·50	28·90	29·34	88	44	62·40	5·85	N.W. & S.W.	5·52
July,	29·43	29·09	29·26	95	46	71·84	6·48	S.W. & N.W.	5·52
August,	29·49	29·09	29·32	98	50	68·68	5·50	S. E. & S.	9·85
September,	29·68	29·01	29·40	94	32	66·90	6·82	S.W. & S.E.	3·40
October,	29·56	28·71	29·14	76	20	49·61	6·12	S. & N.	3·40
November,	29·82	28·74	29·26	48	16	34·83	4·85	N. & N. W.	1·63
December,	29·74	28·55	29·39	56	−12	22·10	4·56	N.W. & S.W	2·63
Year,	29·665	28·543	29·339	98	−19	46·895	5·77	N. W. & N.	55.90

The mean temperature of the past year is 47°·895, being a little above that of the year 1850, which was 47°·200.

The mean temperature of the winter months of 1850–51 is 27°·43; of the spring months of this year 46°·70—being 3°·62 higher than the temperature of the same months in the year 1850. The temperature of the summer months is 67°·64, being 3·86 lower than the temperature of the same months in the year 1850. The temperature of the autumnal months is 50°·45, being ·88 of a degree above the temperature of the same months of the previous year.

The average density of the atmosphere as indicated by the barometer—29·339 inches—is a trifle greater than in the year 1850, it being for that year 29·27 inches when corrected by adding the decimal ·64, which, by comparison with one of Green's barometers—the kind now recommended by the Smithsonian Institute—is found to be the true amount of correction necessary for the barometer then in use.

The observations have been made, as last year, at the hours required by the Smithsonian Institute, viz.: sunrise, 9 A. M., 3 P. M., and 9 P. M.

The amount of rain and melted snow for the year is 55·90 inches, being 4·66 inches more than in the year 1850, though the amount for that year was more than is thought to be the annual average. This amount, as may be seen by the table, was not very equally distributed through the year—being for the month of May 15·46 inches, and for the month of August 9·85, while for the month of March it was only ·55 of an inch, and for the month of November 1·63 inches.

The rains in the month of May occuring mostly in the latter part of the month, amounting in the last day of the month to 4·5 inches, raised the Rock River to an unprecedented height, causing a flood which did much damage, carrying off animals, bridges and dams.

The amount of snow which fell in the winter of 1850–51 was greater than in the winter previous, being nearly 15 inches, but was so equally distributed through the winter as to afford but little sleighing.

The past year is considered usually productive, though some of the crops were greatly injured. The spring was very backward, more so even than the year before, notwithstanding the temperature was a little higher. The heavy rains of May greatly delayed the planting of corn, on which account it was, at first, feared that there would be but a partial crop, but the mild fall and the delay of hard frosts gave abundant time for it to ripen, and it thus became a good crop. The yield of grass was very heavy. The wheat crop was comparatively a failure; much of the spring wheat, especially the hedge-row, being greatly injured by the

blight. Hundreds of acres were not harvested. The winter wheat, and some kinds of spring wheat, however, did well, furnishing an abundance beyond what is necessarily consumed. The crop of oats was very heavy. The yield of potatoes was very light, not being injured, however, so much by the *rot* as by the *blight*, a kind of indefinite term given to some cause which eludes the search of the agriculturist. Some portions of the State, it is understood, were almost destitute of this important vegetable.

Some farmers in this region have commenced the raising of flax, which gives a profitable yield, and is destined to be a crop of much importance both on account of the seed and the stalk. The late invention of a machine for pulling flax has obviated the great objection to the raising of this crop, while the building of mills for the dressing of flax has opened for it a ready market.

The fruit that has been introduced into the country did well the past year, and has kept up the fair promise for the future. In some instances the fruit trees have suffered from the blight. Some grapes were injured by the frost while in the blossom, but those later in flowering did finely.

Garden vines were greatly injured by the heavy rains. Some being entirely drowned out, while others rotted at the roots.

There was no second flowering of plants as noticed last year, except the case mentioned in the calendar on November 10th.

The *Cantharis cinerea* which has made its appearance here in increasing numbers for the few previous years was not observed to any amount. Neither was anything heard of the *chinch-bug*, so troublesome the last two years in the northern counties of Illinois.

There were during the year some heavy storms of electric fluid, particularly in the month of May, frequently striking buildings and other objects elevated much above the ground.

The prevailing winds have been, as last year, northwest and north, though we have quite frequent and strong winds from the southwest. There was a violent wind on the 30th of May, which did some damage by unroofing buildings, removing fences, &c., though its track, as it passed this place, was quite narrow, being but four or five rods in width. Its direction was from southwest to northeast. The law of rotation of the winds, alluded to in the last years abstract, is, in the general, corroborated by this year's observations; there were, however, marked exceptions.

CALENDAR.

January.—2d, Morning, meteor seen in the northeast; 16th, the thermometer fell from 35° at sunrise to 3° at 9 P. M.; tulips and jonquils above ground; humble bee seen flying about; 30th, coldest day in the year, thermometer averaging 11° below zero.

February.—23d, severe storm of thunder and lightning, with rain in the night.

March.—7th, Ranunculus fascicularis in flower; Pæonia humilis and star of Bethlehem up; 16th, bluebirds seen and robins heard to sing—some say that they remain here all winter near houses (?); wood Anemone, Pulsatilla patens in blossom; 24th, meadow lark seen; 27th, wild pigeons seen; Missouri currant in leaf; 29th, bee larkspur in leaf.

April.—2d, frogs singing; 4th, snow storm; 8th, farmers sowing wheat; 12th, spring beauty in flower; 16th, dwarf iris, Dutchman's breeches, blood root and pepperwort in flower; 18th, wild geese flying north, strawberry and jonquils in flower; 24th, asparagus fit to cut, lanced-leaved and hood-leaved violets, periwinkle, filbert and hyacinth in flower; 25th, cherry in leaf, currant in flower; 26th, Missouri currant, plum, cherry and pear in flower; 28th, gooseberry in flower.

May.—3d, Lousewort in flower; 6th, box elder in blossom; 7th, frogs singing the second time, having commenced *too soon* before; 8th, ground ivy, flowering almond in blossom; 8th, blue bell and puccoon in flower; 10th, peach, tulip and painted cup in flower, Baltimore oriole seen; 12th, American cowslip and apple in flower, burr and black oak in leaf—these trees did not blossom this year; 13th, horse-chestnut in leaf; 14th, Solomon's seal and bladder nut in flower; 15th, tartarian-fly-honey-suckle in blossom, locusts begin to put out their leaves; 16th, cranes bill, lilac and daisy in flower; 17th, blue-eyed-grass in flower; 19th, white moccasin flower in blossom; 20th, wild columbine, wild lupine and white oak in blossom; 23d, milk weed in flower; 24th, Virginian anemone and snow-ball in blossom; 25th, Potentilla canadensis in flower; 26th, rose acacia in flower, catalpa and hercules club in leaf; 27th, fringe tree and yellow moccasin flower in blossom; 28th, Polygala senega in flower; 30th, feverwort.

June.—3, sweet scented syringa and spiderwort in flower; 24th, spotted lily in flower.

July.—15th, one of the two hottest days of the year, the thermometer averaging for the day 83¾°; 16th, catalpa in blossom; 20th, Bignonia rachicans in flower; 26th, the other hottest day, the thermometer averaging the same as on the 15th.

August.—27th, some say there was frost.

September.—10th, splendid aurora; 28th, heavy frost.

October.—23d, water froze and ice formed 1½ inch thick.

November.—4th, first snow; 10th, Flos adonis in full bloom.

December.—15, thermometer 19° below zero at 5¾ A. M.

ART. XXIX.—*Solidification of the Rocks of the Florida Reefs, and the Sources of Lime in the Growth of Corals;* by Professor HORSFORD, of Harvard.

I. It is required to ascertain by what processes, chemical or mechanical, or both chemical and mechanical, the surface and the submerged coral rocks have become hardened.

By the surface rock is intended that thin brown crust, composed of numerous layers, which is distinguished by great compactness, and a peculiar ring, when, in detached condition, it is struck by a hammer, and which occurs on the abrupt ocean side, and more abundantly on the long slopes on the land side of the Keys.

By the submerged rock, is intended the rock of oolitic appearance which has solidified under water, and which is of inferior hardness to the surface rock.

The surface rock, so called, has in many places no longer the outermost position, though it had at the time of its formation. It is indeed interstratified with friable light-colored limestone. The epithet indicates the circumstances of its formation, not its present position.

1. We are familiar with the fact that a mixture of quicklime, water and sand, spread out upon walls and ceilings exposed to an atmosphere containing more or less of carbonic acid, in a few days becomes hard. Analyses have shown that two chemical phenomena are concerned in the solidification, to wit.: the absorption of carbonic acid from the air, forming carbonate of lime (which salt, uniting in equivalent proportions with the hydrate, forms, according to Fuchs, a compound of great stability); and the union of the outer portions of the sand-grains with the lime, forming a silicate. Investigation has shown that sand fulfills mechanically a more important office, by increasing the extent of surface to which the compound of the hydrate and carbonate may attach itself. The latter office may also be performed, and equally well, by pulverized limestone.

2. It is well known that calcareous springs deposit carbonate of lime in crystalline forms. The salt had been held in solution by carbonic acid contained in the water. Upon reaching the surface under less pressure and the influence of a high temperature, its carbonic acid is given up, and with it a precipitate of carbonate of lime takes place. The process is exclusively chemical.

3. The value of hydraulic cements is now conceived to depend chiefly upon the presence of silica and lime, the oxyd of iron having little or nothing to do with the process of solidification. The alumina, in the form of a silicate, yields its silica to the lime, which, for its transportation, requires water. This explains the necessity of its being retained under water periods of variable

length, according to the proportions of the ingredients. The processes are both chemical and mechanical.

4. Gypsum from which the two atoms of water of crystallization have been expelled by heat, rapidly hardens upon being mixed with water. This is ascribed to the reunion of the sulphate of lime with the water.

Do either of the above processes suggest the method by which the rocks of the Florida reefs have been hardened?

The facts presented in the furnished specimens are as follows:

The rock formed under water exclusively is composed of grains of size less than that of a mustard seed, which, to the naked eye, appear quite globular and of uniform diameter. More carefully examined with a microscope, they are found to be far from regular in form or uniform in size, but present numerous depressions and prominences. Distributed throughout the intervening spaces is a fine deposit of carbonate of lime, which adheres with considerable tenacity to the surface upon which it rests.

The surface or crust-rock, though not strictly homogeneous, is composed of particles so minute as not to be distinguished from each other. It dissolves in hydrochloric acid, leaving a flocculent residue. The solution, when evaporated to dryness and ignited, readily redissolves in hydrochloric acid, with only an occasional residue. The solution gives no precipitate with chlorid of barium. Nitrate of silver gives, in a nitric acid solution, a white precipitate soluble in ammonia. The aqueous extract gives to alcohol flame the characteristic soda tint. The powdered rock, dried at 100° C., when heated in a dry tube, gives off water.

Thus the qualitative analysis of the incrusting rock showed it to consist of lime, soda, carbonic acid, hydrochloric acid, water, and organic matter. There were also variable traces of peroxyd of iron, magnesia and silica. The former two were wanting in most of the specimens examined, and the silica in some. Numerous specimens were examined for alumina, without in any instance finding a trace of this substance.*

In a quantitative analysis by Homer, and another by Mariner, the following results were obtained.

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* I examined, also, all the species of coral at my command, without finding a trace of alumina in any of them. The hydrochloric acid solution of the coral was precipitated with ammonia. The washed precipitate was digested for several hours with potassa (previously tested for and found to be free from alumina), and filtered. The filtrate was then neutralized with hydrochloric acid, and ammonia added. After standing for several hours, there appeared filaments which were soluble neither in potassa nor nitric acid, and which, examined with the microscope, proved to be paper; they had been derived from the filter. Beside these, there was no precipitate. The quantities employed were, in several instances, from a quarter to half a pound of material. There were examined, Millepora alcicornis; Meandrina labyrinthica, two specimens; Manicina palmata; Mycedia areolata; Astræa microcosmos, two specimens; rock subaërial, and rock submarine, numerous specimens.

The total loss by prolonged ignition included organic matter, water as hydrate of lime and carbonic acid, was as follows:

I. 2·7875 gr. lost 1·2687 gr. II. 0·5910 gr. lost 0·2600 gr.

The water was determined in a chlorid of calcium tube, with the aid of a low red-heat and an aspirator. (A heat of 175° C. in an oil bath, expelled but a very small proportion of the water.)

I. 0·7519 gr. lost 0·0259 gr. II. 1·2890 gr. lost 0·0280 gr.

The organic matter was determined by washing on a dried filter the hydrochloric acid residue.

I. 1·7181 gr. gave 0·0028 gr. II. 0·4461 gr. gave 0·0021 gr.

The carbonic acid was determined in an evolution flask glass. The results with different specimens varied greatly, and are far from being satisfactory.

I. 0·8605 gr. lost 0·3347 gr. III. 0·1720 gr. lost 0·0585 gr.
II. 0·1745 gr. lost 0·0600 gr. IV. 1·6116 gr. lost 0·6277 gr.

The lime was precipitated as oxalate and weighed as carbonate.

I. 1·3248 gr. gave 1·2581 gr. II. 0·2550 gr. gave 0·2330 gr.

The silica was determined in the usual way.

I. 1·3245 gr. gave 0·0002 gr. II. 0·3760 gr. gave 0·0005 gr.

The chlorine of the chlorid of sodium was determined as chlorid of silver.

I. 0·8933 gr. gave 0·0303 gr. II. 0·6850 gr. gave 0·0101 gr.

Expressed in per cents. we have:—

Volatile Matter	from	-	43·99 p. c.	to	45·51 p. c.
Water	"	-	2·17	"	3·44
Organic Matter	"	-	0·16	"	0·47
Carbonic Acid	"	-	{ 34·01 { 34·38	"	{ 38·89 { 38·94
Lime	"	-	51·17	"	53·12
Chlorid of Sodium	"	-	0·04	"	0·04
Silica	"	-	0·01	"	0·01

It is conceivable that the variability in the carbonic acid and water, is due to the more or less advanced stages of change which the rock has undergone. In the ultimate form of limestone all the water existing as hydrate in the earlier stages, will have become carbonate.

These ingredients permit no action like that occurring in hydraulic cements, in which silica plays an important part; or like that presented in the hardening of gypsum, in which sulphuric acid is necessary. To one of the two remaining processes, if to either, must it be ascribed; and as hydrate of lime is present, it cannot be exclusively assigned to a place with calcareous spring

deposits. Now, how could hydrate of lime be provided from carbonate of lime?

The completeness of the suite of collections provided for me by Prof. Agassiz, has enabled me to answer this question in such a manner as leaves, I think, little room for doubt. On the main land against the Keys, there are depressions which are filled with water only at long and irregular intervals. This water, like that within and about the Keys, abounds with animal life. As the water evaporates, these animals die, and fall upon and mingle with the coral mud at the bottom. As the beds become more and more completely dry, the layer of mud and animal matter hardens till it forms a mass resembling the surface or crust rock.

Of this soft, growing rock, specimens were collected. Agitated with water, it yielded a turbid, fœtid solution. Tested with acetate of lead, it betrayed the presence of hydrosulphuric acid. After standing some hours, a delicate white film was deposited upon the containing vessel, at the surface of the water, which proved to be carbonate of lime. Test-paper showed the liquid to be alkaline. The addition of soda solution set ammonia free, and the addition of chlorid of barium and hydrochloric acid showed the presence of sulphuric acid.

Conceiving this soft rock to be in the condition in which the solidified crust was at first, the process of hardening seemed of easy explanation.

The animal matter mixed with the carbonate of lime, containing sulphur and nitrogen, besides carbon, hydrogen and oxygen, in the progress of decay, which warmth and a small quantity of water facilitated, gave, as an early product of decomposition, hydrosulphuric acid; this, by oxydation at the expense of the oxygen of the atmosphere, became water and sulphuric acid. The sulphuric acid coming in contact with carbonate of lime, a salt soluble in 10,600 parts of water, resolved it into sulphate of lime, a salt soluble in 388 parts of water. The carbonic acid set free, uniting with an undecomposed atom of carbonate of lime, rendered it soluble. The nitrogen going over into the form of ammonia, at a later period, decomposed the sulphate of lime, forming sulphate of ammonia and soluble hydrate of lime. This hydrate of lime, with an atom of carbonate of lime, united to form the compound in ordinary mortar investigated by Fuchs. The carbonate of lime in solution from the added carbonic acid, as the water is withdrawn by evaporation, takes on the crystalline form, giving increased strength and solidity to the rock.

That this explanation may serve, in however small measure, for the crust rock on the land slopes of Key West and all localities of a similar character, it is necessary that there be animal exuviæ in coral mud, or finely divided carbonate of lime. Both these occur. The water about the Keys abounds in animal life.

With the influx of the tide, the slopes become overspread with the water and what it contains in suspension. The retreating water, at ebb tide, leaves a thin layer of the animal matter, mixed always when the water is agitated with the fine calcareous powder. Before the return of flood tide, exposure to the atmosphere and warmth have secured the succession of chemical changes enumerated above, and a thin layer of rock is formed. A repetition of this process makes up the numerous excessively thin layers of which this rock is composed.

On the ocean side the deposit is formed from spray, during winds which drive the froth of the sea, containing, with coral mud, the exuviæ from the barrier of living corals upon the low bluffs of the Keys.*

To these chemical changes must be added the simple admixture of the animal and vegetable matter, which, like mucilage or glue, fills up the interstices, increases the extent of surface, and with it the cohesive attraction; and still further to the decomposition of the organic matter furnishing carbonic acid, which gives solubility to the pulverulent carbonate of lime.

The exceeding fineness of the coral mud is due in part to the stone plants which flourish in the waters within the reef, and which admit of ready reduction to a powder of extreme fineness. Of these, two species of Millepora, I, II, and one of Opuntia, III, were analyzed by Mr. Scoville in my laboratory.

	I.		II.		III.	
Organic matter,	4·45	4·45	1·26	2·58	4·18	5·72
Carbonic acid,	40·09	39·64	41·08	2·70	37·68	35·81
Sulphuric acid,	0·0056	0·0056	——	——	——	——
Lime,	47·71	47·98	46·35	46·80	51·81	51·36
Magnesia,	——	——	6·23	5·90	——	——
Water,	3·67	3·30	4·52	——	5·59	5·92
	95·92	95·37	99·44	8	99·26	98·81

* Professor Dana in a note to his last paper on Coral Reefs and Islands in the July number of this Journal, p. 83, after enumerating briefly the details of the above process of consolidation, remarks:—

"In the first place, his (Prof. H.'s) paper only alludes to the rock formed above low-tide level, which I have called the coral sand-rock. Again, the amount of organic matter in corals, as found by analysis, does not exceed five per cent.; and the sulphur present in this organic matter, is not over *one-tenth of one* per cent. It hence appears that the amount of sulphur is altogether inadequate for such changes.

"But as the sands of the beach (which have a peculiarly white and clear appearance) are washed by the breakers, and the animal matter they contain is either undecomposed within the several grains, or is borne off by the waters, even the animal matter present cannot contribute to the consolidation. The waters of the tides along a sand beach on the open ocean have certainly not been proved to carry in dissolved animal matter for dissemination among the sands."

Two or three points in this note demand attention from me.

The first sentence of the first paragraph should be read in connection with the conclusions I and II, expressed at the end of my paper.

In reply to the remainder of the paragraph, the criticism would be just, if I had any where ascribed the solidification, or any part of it, to any action of the organic matter in corals.

Since the publication of my article in the Proceedings of the Association, there have been made quantitative analysis of the more important ingredients of the soft rock, corresponding, as I conceive, with the rock of sub-aerial solidification in the

The discrepancies in the analyses of the different specimens of the same species are due to the circumstance that different parts of the stone plant contain organic matter in unlike proportions; and it is very difficult to procure two specimens which, when

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first stages of its formation. When first supplied to me, it was of the consistency of well tempered pottery clay. It is now so hard as to yield only to a severe blow with a hammer, and is, beside, brittle and coated with fibrous crystals of common salt.

The following analysis made by Everett and Warren, upon samples differing but little from each other in appearance, have been conducted with great care. They vary, it will be seen, considerably from each other:—

Dried at a temperature of 100° C.	By prolonged ignition.
I. 1·1450 gr. lost 0·0890 gr.	0·8270 gr. lost 0·4870 gr.
II. 1·5325 gr. lost 0·1175 gr.	1·9020 gr. lost 0·8000 gr.

The hydrochloric acid solution left a residue of organic matter.

I. 1·1450 gr. gave 0·2930 gr. II. 1·6424 gr. gave 0·2805 gr.

The mass, digested in diluted hydrochloric acid, yielded from existing sulphate upon the addition of chlorid of barium to the filtrate, sulphate of baryta.

I. 2·3380 gr. gave 0·1040 gr. II. 1·5325 gr. gave 0·1304 gr.

The organic matter by itself, oxydated in nitro-hydrochloric acid, with addition of pulverized chlorate of potassa, yielded to chlorid of barium a precipitate of sulphate of baryta.

I. 1·5325 gr. gave 0·1505 gr.

The whole mass oxydated in a mixture of fused nitrate of potassa and carbonate of soda, yielded to chlorid of barium and hydrochloric acid, a precipitate of sulphate of baryta.

I. 2·3090 gr. gave 0·2850 gr. II. 1·4322 gr. gave 0·1550 gr.

The hydrochloric acid solution filtered from the organic matter gave a precipitate of oxalate of lime, which was determined as carbonate.

I. 0·8770 gr. gave 0·4100 gr.

Expressed in per cents. the above determinations give of

Water, expelled at 100° C.

I. 7·77 p. c. II. 7·66 p. c. Average, 7·72 p. c.

Total volatile matter,

I. 41·17 p. c. II. 42·06 p. c. Average, 41·58 p. c.

The following per cents. are estimated upon the substance as dried at 100° C.

Sulphur existing as sulphate and soluble in diluted hydrochloric acid.

I. 0·65 p. c. II. 0·90 p. c. III. 1·26 p. c. Average, 0·94 p. c.

Sulphur in organic matter.

I. - - - - - - - 1·45 p. c.

Total sulphur of the above determinations, 2·39 p. c.

Total sulphur by oxydation of the mass, including the organic and inorganic parts.

I. 1·61 p. c. II. 1·84 p. c. Average, 1·72 p. c.

Average by the two methods, - - - - 2·05 p. c.

Lime, I. - - - - 30·09 p. c.

Placing side by side the results of the above determinations with the quantities which Prof. Dana justly conceives to be inadequate to the changes ascribed, we have

	Per cent.	Per cent.
Organic matter, - - - - -	5·	20·16
Sulphur, - - - - -	0·1	2·05

The conditions of this soft rock, and of the surface or crust rock at the time of its formation, I conceive to have been quite identical. The soft rock is the residue left

pulverized, will present homogeneous powders of the same constitution.

II. *Source of Lime in the Growth of Corals.*

Marcet,* as early as 1823, observed carbonate of lime in the sea-water near Portsmouth. Jackson† found it in two specimens of sea-water furnished by the United States Exploring Expedition; one from 600 feet, and the other from 2,700 feet below the surface. J. Davy‡ found the sea-water of Carlisle Bay, Barbadoes, to contain about $\frac{1}{1\,8\,0\,0}$th part of carbonate of lime. There was found scarcely a trace near the volcanic island of Fayal. White‖ is of the opinion that it fails only near the surface; but the elaborate analysis by Bibra§, of no less than ten specimens taken generally from a depth of twelve feet, but in one instance from a

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by spontaneous evaporation of a considerable body of sea-water thrown, with its mingled coral mud and animal matter, into an inland basin, at the rare juncture of favorable high wind and tide. A single layer of the surface rock is the residue left by evaporation of the water mingled with coral mud and animal matter, thrown up in spray from the dashing of the waves, or carried up by flood-tide, and left by evaporation in the interval between the two tides. This will account for its stratification, for its occurrence on eminences as well as in depressions and along abrupt slopes, for its interstratified arrangement with the coarse coral sand; indeed, for all the phases and peculiarities of it which are presented in the extensive suite of collections submitted to me.

In addition to the changes enumerated in the above paper as resulting from the decay of the animal matter, another may be mentioned. The ammonia evolved in the process of decomposition, would provide hydrate of lime from the sulphate present in the sea-water. This ingredient, taking the average of Bibra's analysis, is to the chlorid of sodium as 1 to 16, and may be conceived to have furnished no inconsiderable amount of hydrate of lime for the process of consolidation.

Prof. Dana attributes the formation of this crust-rock which has been the more prominent object of my investigation, to the action of simple rain-water, dissolving the carbonate of lime and again depositing it upon evaporation.¶ This would account for its occurrence in depressions of the rock, but would not account for its occurrence on eminences or on abrupt slopes; nor would it account for the presence of water as hydrate of lime.

The first sentence of the second paragraph of the above criticism has been replied to. I have ascribed no solidifying action to the animal matter in corals.

In regard to the second:—It will not be questioned that there is a great amount of organic matter in various stages of decomposition about coral reefs. Bibra found organic matter in all the ten specimens of sea-water analyzed by him. I have, in the paper above, repeated the statement made to me by the parties who collected the specimens, that the waters within the Keys abound in animal life. That procured for analysis from within the Keys was found exceedingly offensive from the decomposition of animal matter. It yielded the odor and reactions of hydrosulphuric acid, and gave a total amount of organic matter of 2·98 per cent.

Now, it is difficult to see how sea-water should fail to carry the animal matter it holds in solution, and more or less of that it holds in suspension into the coral sands, which are saturated at every high water and again drained at low tide.

* Annals of Philosophy, April, 1823, p. 261.
† Am. Jour. Science, [2], vol. v, p. 47.
‡ Phil. Magazine, [3], xxxv, p. 232.
‖ Ib., p. 308.
§ Ann. de Chemie et de Pharmacie, lxxvii, 90.
¶ Am. Jour. Sci. [2], xiv, 77 and 81.

depth of four hundred and twenty feet, in various latitudes on both sides of the equator, shows quite conclusively that it is not a constant ingredient of sea-water. His analyses do not mention a trace of carbonate of lime. The quantity found by Davy is very nearly that which is soluble in water, and is obviously due to the calcareous marl which abounds near the Barbadoes.

The water from within the Keys was carefully analysed in my laboratory: it contained lime and sulphuric acid among its ingredients, but not a trace of carbonic acid.

The total want of carbonic acid in a water in which coral life is so luxuriant, suggests naturally that the stone plant, as well as the coral animal, possesses the power of abstracting lime from the sulphate; the change being due to double decomposition with carbonate of ammonia excreted from the plant and animal, yielding carbonate of lime, quite insoluble, and sulphate of ammonia of the highest solubility. The building up of the calcareous skeleton becomes, upon this hypothesis, of exceeding simplicity. The surrounding element yields at once to the exhaling carbonate of ammonia the framework of stone.

With this view, there is no difficulty in finding a supply of carbonate of lime for the vast masses of coral. The sulphate of lime, decomposed to furnish the carbonate, is perpetually renewed through rivers from the continents and islands.

The following inferences are legitimately deducible from this view:—

1st. Corals would soon die in bodies of salt water wholly cut off from the ocean.

2d. They might flourish to some extent in waters accessible to the sea only at high tide.

In Dana's Report on Coral Reefs and Islands,* he states that "where there is an open channel, or the tides gain access over a barrier reef, corals continue to grow, etc. At Henuake the sea is shut out except at high water, and there were consequently but few species of corals, etc. At Ahii there was a small entrance to the lagoon; and though comparatively shallow, corals were growing over a large portion.†

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* Am. Jour. Science, [2] xii, 34 to 41, and Geol. Report Expl. Exp., p. 63.

† In my article, as published in the Proceedings of the Association, I have further quoted from Prof. Dana's papers in support of other inferences deduced from the foregoing view. I have since learned from the author that I had misconceived the sense in which the quotations were to be understood, and have become satisfied, especially after examination of the map of the Feejee Islands accompanying Prof. Dana's last article, that the inference that fresh water streams, by their supply of sulphate of lime, exerted any considerable influence upon coral formations, is not sustained. The sulphate of lime of sea-water, however, being one-sixteenth of the chlorid of sodium, is abundant for the supply of the carbonate of lime, without the aid to be derived from such a source.

These facts seem to me to give some support to the view expressed above.

It was of interest to ascertain, in the case of corals, whether the formation of new coral without was attended with absorption or partial solution in the interior, and a corresponding reduction of its specific gravity. Specimens of coral, from the centre, periphery, and midway between, of a mass of Meandrina a foot in diameter, were reduced to powder, washed with hot water until the chlorid of sodium was all removed, and their specific gravity ascertained by Storer. The average of three specimens from the centre, three from the middle, and two from the periphery, gave the following specific gravities:—

Centre.	Middle.	Periphery.
2,695	2,749	2,785

These results so far support the affirmative of the suggestion above, as to make a repetition of the determinations desirable.

The chief conclusions to which the above research has conducted are:—

I. That the submerged or oolitic rock has been solidified by the infiltration of finely powdered (not dissolved) carbonate of lime, increasing the points of contact; and the introduction of a small quantity of animal mucilaginous matter, serving the same purpose as the carbonate of lime, that of increasing the cohesive attraction.

II. That the surface rock has been solidified by having, in addition to the above agencies, the aid of a series of chemical decompositions and recompositions resulting in the formation of a cement.

And I may add that it lends support to the suggestion,

III. That the carbonate of lime of corals is derived from the sulphate in sea-water, by double decomposition with the carbonate of ammonia exhaled from the living animal.

[*Note.*—Mr. Dana will add some farther explanations and criticisms on the subject of Prof. Horsford's paper in another number of this Journal.—Eds.]

ART. XXX.—*Note on the Eruption of Mauna Loa;* by JAMES D. DANA.*

THE account of Mauna Loa, by Rev. Titus Coan,† together with the additional information from letters appended to this paper, suggests a few thoughts confirmatory of views mentioned in another place by the writer.

I. The eruption described, although so vast in its extent, commenced with no earthquake—no internal thunderings—no premonitions whatever that were perceptible at the base of the mountain. In almost all descriptions of volcanoes, these phenomena are set down as essential to the result, especially if the eruption be of much extent. Some force is supposed, in one way or another, to get beneath the column of lava, and by sudden action to eject the lavas with violence, amid terrific exhibitions of volcanic power. But in the majestic dome of Mauna Loa, where the lavas are carried to a height of 14,000 feet, the outbreak is quiet and noiseless; the mountain opens, the lavas flow. The vivid description of Mr. Coan, marked as it is with the actual terrors of the scene, strikingly sustains these statements. For how unlike Vesuvius in her great outbreaks is the Hawaian volcano, when the crater, in its intensest eruption, could be approached "within forty or fifty yards on the windward side," or "within two miles on the leeward," and the traveller need retire but to the distance of "a mile" from the very scene of eruption for his "night vigils."

II. The mobility of the Hawaian lavas is most remarkably exemplified in this eruption. The fiery rock at the crater formed literally an open boiling fountain, instead of appearing in eruptive discharges through a narrow-necked funnel. A *jet* of clear liquid lava shot up in ceaseless flow to a height of 300 feet or more, and, with its surrounding jets and falling spray, produced, as Mr. Fuller says, the effect of a Gothic structure of molten metal, with its shafts and pinnacles and buttresses, in quick incessant change —now rising into a tall spire 700 feet in height, now spreading into more massy forms, and ever dazzling the sight with its brilliancy. The scene of this display, according to Mr. Coan, was 5,000 feet below the summit outbreak,‡ and it would actually appear, as he implies, that the hydrostatic pressure of the central column of lavas in the mountain was the power that kept the jet in action. Such a fountain of molten rock is majestic beyond conception; and the more wonderful, the more majestic, viewed as the effect of simple pressure, with none of the convulsive heavings

* See farther the author's Expl. Exp., Geol. Report, Chapters III and VII; also, this Journal, [2], ix, 347, and x, 235. † This volume, p. 219.

‡ Seven thousand feet, or half way to the base, according to Mr. Fuller.

common in other volcanoes. The terrible roar of the crater was the sound of the ponderous mass agitated to its depths, by the tossing and falling jets and the escape of the imprisoned vapors; it was not enhanced even by the occasional shocks of an earthquake.

III. Kilauea, a crater on the flanks of Mauna Loa, but 4,000 feet above the sea, having its larger diameter 18,000 feet, or 3½ miles, exhibited at this time no signs of sympathy with the summit action.* If ever a region had its *safety valve*, we should say that this immense crater would be such to Hawaii. But the lavas rise in the centre of the mountain 10,000 feet above this vast pit, (or nearly 11,000 feet above its bottom), without producing the slightest fluctuation in its boiling lakes.

IV. From the eruptions of Kilauea in 1823, 1832 and 1840, the writer, in tracing out its history, stated that the course of changes leading to a new outbreak required eight or nine years, this being the interval between the known eruptions. The process was shown to consist in a gradual filling up of the great pit for 400 or 500 feet of its depth, attended with an increased activity when at this height, and followed by a discharge from some fissure or fissures opened through the slopes toward the sea.

But since 1840, thirteen years have passed and still no eruption has been observed. The process has, however, been essentially as indicated by the author, although under a new modification of its action. The crater did go on filling up at its usual rate, so that in 1846, it had already risen to a height of 400 feet above the level it had after the eruption of 1840.† The crater, moreover, was then in violent activity, and the black ledge was nearly obliterated; the bottom continued still to rise, and an eruption was speedily expected. But instead of an eruption, we learn that in 1848 and 1849,‡ all was nearly quiet, excepting a single convulsive heaving in the latter year. The lower pit was filled with solid lavas, and the great lake became finally the site of a solid dome or cone.

It is however altogether probable, from the retreat of the liquid lavas and the disappearance of the fires, that a discharge actually took place at the time expected, but beneath the sea. Such a discharge occurring in the usual quiet way, might be unperceived by the inhabitants of the island. The outflow of lavas, however, must have been but a partial one; and, consequently, the bottom of Kilauea, instead of subsiding, as the lavas retreated, 400 feet (as commonly happens), retained its place.

Five years have now passed, and the fires, as Mr. Coan states, are again breaking out. This is a further confirmation of our view.

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* This volume, p. 220.

† See the author's papers referred to. Also a detailed account, by Rev. C. Lyman, in this Journal, [2], xii, 75.

‡ This Journal, [2], ix, 362, and x, 80.

The process of elevation in the liquid internal lavas has evidently been going on, as after previous eruptions, although out of sight, deep beneath the solid rock that forms the bottom of Kilauea; and they have again reached a height that enables them to be distinguished. The mode of progress and of eruption may therefore correspond throughout with the views presented by the author in his Exploring Expedition Geological Report, and this Journal, vol. ix, 347. Yet it is also possible that the fires of Kilauea are dying out and that thus the change of condition is to be explained.

Although the discharges at the summit of Mauna Loa produce no oscillations in the lavas of Kilauea, it may still be possible that the increased activity at the summit, and the diminished action of the flank crater, during the past few years, may be connected with the same changes below. These changes may consist in some variations in the distribution of the heat, or, more probably, in a variation of size or direction in the openings or channels that serve to supply the water which feeds the fires.

V. If Kilauea were to become extinct in its present condition, no evidence would exist of its former depth, or of the black ledge or shelf which has been so remarkable a feature in this crater. The present depth does not exceed 600 feet—400 feet less than after the eruption of 1840.* Moreover, as the precipitous rocky walls are wholly free from scoria and all other signs of recent fires (looking much like bluffs of ordinary stratified rock), there is no evidence as to the great eruptions that have taken place, and only signs of a sort of Solfatara action with outflows of lava over the bottom of the confined area. These facts bear on the conclusions that might be deduced from the existing features of extinct volcanoes.

VI. Mr. Coan speaks of the lavas as flowing from an orifice in a broad stream down the mountain. It is probable that fissures opening to the fires below were continued at intervals along the course of the eruption, and that these afforded accessions to the fiery flood. Such was the case in 1840, and the three tufa hills at Nanawale, on the sea-coast, mark the positions where these opened fissures reached the sea. Any internal force sufficient to break through the sides of a mountain like Mauna Loa, must necessarily produce a linear fissure or a series of fissures, and not a single tunnel-like opening.

VII. We have yet received no definite facts as to the angle of slope down which the lavas descended. Yet we do know that in this and in a former eruption the stream continued over the declivities for thirty miles, and these declivities have an *average* angle of six or seven degrees, though made up of subordinate slopes varying probably between one and twenty degreees, as Mr.

* The central portions of the crater are much more raised than the lateral, and over them the depth cannot exceed 500 feet.

Coan mentions when describing the descent of the lavas in the summit eruptions of 1843.* The slopes of Mauna Loa, although the mountain is over 14,000 feet high, are therefore not too steep to receive accessions from top to bottom, from eruptions of vast extent over its sides. With such facts, in connection with others brought forward by the writer, we are assuredly sustained in not admitting the universal application of the so-called *elevation* theory. But in rejecting this theory, we do not go to the opposite extreme, and adopt in its full extent the *overflow* theory. The truth, as usual, lies between the two extremes, as the writer has elsewhere urged. Both causes have acted in the history of all volcanoes; both act from the very commencement of the germ-cone. There is elevation from the central action, from the opening and filling of fissures about the centre, and also from the outflow of lavas. The first of these operations may be most effective in the earlier periods of the rising mountain; but each continues to act till the fires die out; and in the later periods, especially, there is often a *flattening* process, arising from the spread of lavas ejected from fissures about the base of the mountain, which extend the shores, and diminish the angle of slope.

VIII. The interval of time between the last three eruptions of the central crater of Mauna Loa is nine to ten and a half years. The *first* of these three took place in June, 1832; the *second* in January, 1843; the *third* in February, 1852. The recorded eruptions of Kilauea have occurred as follows, leaving out that of 1789: the first in 1823, the second in 1832, the third in 1840, probably a fourth through a submarine or subterranean vent in 1847 or 1848, and the fires are now increasing again in activity. In 1832 there were thus eruptions from both of these extensive craters of Mauna Loa.

We annex additional notes on the eruption from different sources. The account of the *whirlwinds* produced by the crater are of much meteorological interest.

1. *From a Letter of H. Kinney, dated Waiohinu, Hawaii, April* 19, 1852, (published in "The Pacific," San Francisco, of June 18.)

The light of the volcano, at night, was very great—illuminating the surrounding country for many miles distant, and giving to the overhanging clouds the appearance of an immense body of fire. After witnessing this for several nights, my desire to visit it became so strong, that I resolved to make the long and tedious journey, to take a near view of this grand display of the Almighty's power. Accompanied by Mr. Fuller, I set out on the 1st day of March. After travelling through woods and over wide districts of naked lava, we arrived at the vicinity of the eruption on the forenoon of the third day. Its deep, unearthly

* This Journal, [2], x, 244.

roar, which we began to hear early on the day before, "waxed louder and louder," as we drew nearer and nearer the action, until it resembled the roar of the ocean's billows when driven by the force of a hurricane against a rock-bound coast, or like the deafening roar of Niagara.

We first reached the deep channel, through which a wide stream of liquid lava had flowed down the mountain, desolating an area of vast extent; it had ceased to flow in this direction, but was flowing still at a little distance, where we gazed with delight. The main stream was still beyond, which we could not approach, on account of the great heat; but at night we had a fine view of the fiery river, at no great distance from our encampment. Though the lava gushed out in several places like water-springs, yet the main fountain was one of indescribable grandeur. In the midst of a forming cone, with a base of 200 or 300 feet there shot up a jet of clear liquid lava to the height of from 400 to 800 feet, combining in its ascent and descent all the beauties of the finest water fountains—jet after jet ascended in constant and regular succession, day after day; descending, it mostly fell back into the crater, but sometimes it fell spattering on its sides, and flowed down, uniting with the main stream. The outer portions cooled to a blackened mass while in the air; the upper and lighter portions were carried by the propelling force to the regions of the clouds, and fell in showers over the surrounding country.

The intense heat of the fountain and stream of lava, caused an influx of cool air from every quarter; this created *terrific whirlwinds*, which constantly stalking about, like so many sentinels, bade defiance to the daring visitor. These were the most dangerous of any thing about the volcano. Sometimes we were compelled to prostrate ourselves for safety. Once we ventured within about a quarter of a mile of the great jet; soon one of the most terrific whirlwinds formed at the crater, and advanced straight towards us, threatening us with instant ruin; but fortunately for us, it spent its force and turned to the right, leaving us to make a rapid retreat.

We saw a similar one whirling around the jet, and concealing it with a dense cloud of ashes, as if engaged in a furious combat. The two contending elements presented a most wonderful spectacle. When the strife ceased, the fountain appeared in constant action, as though nothing had occurred. Clouds approaching the volcano were driven back, and set moving in wild confusion.

The glare of the liquid fountain was very great, even when the sun was shining; but at night it was vastly more so, casting the light of nearly a full moon in the shade, and turning night into day.

2. *From a Letter by Mr. Fuller, dated Waiohinu, March* 28.

There played a *fountain of liquid fire* of such dimensions and such awful sublimity, shaking the earth with such a constant and deafening roar, that no picture of the classic realms of Pluto, drawn by Grecian or Roman hand, can give you any adequate conception of its grandeur. A few figures may assist your imagination in its attempts to paint the scene. I made the following calculations, after careful observations during nearly twenty-four hours, from different points within a

mile of the crater, and, after deliberate discussion with Mr. Kinney and companion, with different objects around us. Some of these calculations have been confirmed by a somewhat accurate measurement by Mr. Lyman, of Hilo.

The diameter of the crater, which has been entirely formed by this eruption is about 1,000 feet, its height from 100 to 150 feet. One part of the crater was raised 50 feet during our presence on the spot. The height of the column of red-hot liquid lava, constantly sustained above the crater, varies from 200 to 700 feet, seldom falling below 300. Its diameter is from 100 to 300 feet, and rarely perhaps reaching 400 feet. The motions of this immense jet of fire were beautiful in the extreme, far surpassing all the possible beauties of any water fountain which can be conceived; constantly varying in form, in dimensions, in color and intensity; sometimes shooting up and tapering off like a symetrical Gothic spire, 700 feet high; then rising in one grand mass, 300 feet in diameter, and varied on the top and sides by points and jets, like the ornaments of Gothic architecture. The New Yorker, who, as he gazes on the beautiful spire of Trinity Church, can imagine its dimensions increased three-fold, and its substance converted into red-hot lava, in constant agitation, may obtain a tolerable idea of one aspect of this terrific fire fountain. But he should stand at the foot of Niagara Falls, or on the rocky shore of the Atlantic when the sea is lashed by a tempest, in order to get the most terrific element in this sublime composition of the Great Artist. For you may easily conjecture that the dynamical force necessary to raise 200,000 to 500,000 tons of lava at once into the air would not be silent in its operation.

The eruption of which I have written broke out on the morning of the 18th of February, at about 3 o'clock, and continued twenty days. The crater is situated on the base of Mauna Loa, about 35 miles from Hilo, and 25 from the old crater of Kilauea. Its height, above the sea, is about 7,000 feet. It has formed a stream, winding down the mountain side, with several branches 30 or 40 miles long, from one-fourth to two miles broad, having a depth, in some places, of 200 or 300 feet.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Determination of Arsenic in Organic Substances.*—Schneider has proposed a method of determining the presence of arsenic, based upon the fact that arsenous acid, in the presence of sulphuric acid and metallic chlorids, is converted into chlorid of arsenic and volatilizes with the vapor of chlorhydric acid under 100 C. Experiment has shown that the presence of organic matter, even in great excess, does not prevent the formation of chlorid of arsenic; and that by distillation all the arsenic can be isolated from the organic substance. The arsenic must be in the form of oxyd or chlorid, and no other oxydizing substance should be present. The substance to be investigated is cut into small pieces, and introduced into a tubulated retort; fragments of fused chlo-

rid of sodium are to be added, and a sufficient quantity of water to cover the mixture. The retort is to be connected with an empty receiver, and this by a tube bent twice at right angles, with a flask containing distilled water and cooled externally. Sulphuric acid is to be introduced into the retort, in small portions at a time, through a Welter's safety tube, and the retort very slowly heated. The distillation goes on quietly, and there is but moderate foaming when the proper quantity of water is used: the boiling is to be continued as long as a portion of the distillate, tested with sulphuretted hydrogen, gives a yellow precipitate. It is best to employ in this process an excess of salt, to prevent the formation of sulphurous acid; fused salt gives the most constant and lasting evolution of gas. When the distillation is over, the distillate is to be oxydized very carefully by means of nitric acid, or chlorate of potash, to determine the arsenic quantitatively, as arsenate of ammonia and magnesia. The residue in the retort contains no traces of arsenic. [The method here given appears to deserve attention, but it must be borne in mind that antimony would probably be volatilized in the same manner as arsenic under the circumstances. The process would admit of ready verification by a repetition of the whole distillation, in a fresh apparatus, with the chemical materials used in the previous investigation, but without the substance to be tested for the presence of arsenic.] —*Pogg. Ann.*, lxxxv, 43.

2. *Identity of Donarium with Thorium.*—The results of Damour's investigation of the supposed new metal donarium, have already been noticed in this Journal. Prof. Berlin, of Lund, in Sweden, has also studied the subject, and, like Damour, infers from his analysis that orangite is identical with thorite, and, consequently, donarium with thorium. Bergemann has, however, continued his researches, and while expressing himself with due caution, is not prepared to admit the conclusions of the French and Swedish chemists, so that some doubt may still be entertained upon the subject.—*Pogg. Ann.*, lxxxv, 555.

3. *Conversion of Sulphates into Chlorids.*—Rose has found that the alkaline sulphates are converted into chlorids by repeated ignition with chlorid of ammonium. This method cannot, however, be employed when the sulphates of lithia or magnesia are present, as these salts are not decomposed by sal-ammoniac.—*Berliner Monatsberichte, February*, 1852.

4. *Anhydrous Organic Acids.*—Gerhardt has succeeded in isolating acetic and benzoic acids, $C_4H_3O_3$ and $C_{14}H_5O_3$, and in pointing out a method by which many other bodies of a similar nature may doubtless be obtained. When an equivalent of dry benzoate of soda is carefully heated in a sand bath, with an equivalent of oxychlorid of benzoyl a reaction takes place which is expressed by the equation

$$C_{14}H_5O_3, NaO + C_{14}H_5O_2Cl = NaCl + 2C_{14}H_5O_3.$$

The mass in the retort, washed with water and carbonate of soda, leaves a white substance crystallizing in beautiful oblique prisms fusing at 33 C., entirely neutral and volatile without decomposition. This substance is the anhydrous benzoic acid, $C_{14}H_5O_3$, which boiling water gradually transforms into ordinary benzoic acid, $C_{14}H_5O_3 + HO$; caustic alkalies effect this transformation almost instantly. Heated with

alkaline cinnamates, cuminates or salicylates, the oxychlorid of benzoyl produces what may be termed double acids, that is to say, compounds of two anhydrous acids. These are oily liquids, inodorous and insoluble in water, but rapidly converted by boiling water into mixtures of the hydrated acids. Anhydrous acetic acid is obtained by heating the oxychlorid of benzoyl with an excess of fused acetate of potash. It is a perfectly colorless mobile liquid, highly refracting and possessing a very strong odor analogous to that of glacial acetic acid but more powerful. It boils at 137° C.: it is heavier than water with which it does not mix; by long agitation, however, with water, or by gentle heating, it is dissolved and converted into ordinary acetic acid. By the action of the oxychlorid of phosphorus upon the acetates, Gerhardt has succeeded in obtaining the oxychlorid of acetyl, $C_4H_3O_2Cl$, as a colorless liquid boiling at 56° C., and readily decomposed by water into acetic and chlorhydric acids.—*Comptes Rendus*, xxxiv, 755.

[*Note.*—It will be seen that the method employed by Gerhardt is identical in principle with that used by Williamson in preparing his new alcohols. The same questions arise in this case as in the case of the alcohols cited. Gerhardt doubles the formulas of the anhydrous acids which he has discovered, and unites them (in the ordinary equivalents) $C_{28}H_{10}O_6$ and $C_8H_6O_6$, or using his own equivalents, $C_{14}H_{10}O_3$ and $C_4H_6O_3$. The whole question of the constitution of the new compounds depends upon this: can a given molecule unite *chemically* with another molecule of the same species so as to form a third molecule of a different species? There are at present, we believe, no means of answering this question, and the views of Williamson and Gerhardt are pure assumptions not based upon any known facts, as is also the idea that the equivalents of all organic bodies must be represented by four volumes of vapor. Gerhardt's fine discovery only lends new strength to the views of Berzelius with reference to the organic acids, by pointing out the great analogy which exists between the anhydrous organic acids and the anhydrous inorganic acids as SO_3 and NO_5.—W. G.]

5. *Equivalents of Sulphur and Barium.*—Struve has determined the equivalent of sulphur by reducing sulphate of silver by hydrogen. A mean of six determinations gives 16·001 or 200·00, which confirms the correctness of the received number. The same chemist has also determined the equivalent of barium by decomposing the chlorid of barium by sulphuric acid, and weighing the resulting sulphate. As a mean of two experiments he obtained the number 68·13 or 851·62.—*Ann. der Chemie und Pharmacie*, lxxx, 203. W. G.

6. *On the Corrosion of Lead by Galvanic action;* by R. Buckler, (from a letter to the editors, dated Baltimore, July 16th, 1852.)—I am perfectly aware that the corrosion of lead by galvanic action, induced by uniting lead with other metals under water is a well known fact first proved by the experiments of Dr. Paris of England; and being well known, I am surprised that so little attention has been given to it, when we consider the suffering brought on by impregnating the system with lead.

A case recently occurred here, which demonstrates clearly the impropriety of connecting lead with another metal under water. A gen-

tleman residing near the city having occasion to get the pump supplying his house with water repaired, it was found on examination that the portion of the lead pipe connected to the pump by a brass coupling, was to the extent of an inch almost entirely destroyed and only held together by a few shreds of lead. As it seemed impossible that this could have been caused by the action of the water alone, more especially as the rest of the pipe was entirely uninjured, I was requested by Dr. T. H. Buckler to examine the water, both as to its action on lead and chemical constituents. I procured some of the water, and the following is an extract from a note which was sent with the water. "This water is forced from the well by a brass or copper-force pump through a lead pipe; it has been in use since 1847. This year the pump became out of order, when a leak was discovered in the lead pipe at its connection with the brass coupling which joins it to the pump, the lead being nearly all destroyed. An inch from the connection the lead was apparently as perfect as when first used nor can we discover that any other part of it has been affected either by the water or the other metal."

About four ounces of the water were placed in two beaker glasses. In No. 1 a bright strip of lead was immersed; in No. 2 a strip of lead and brass connected. In order to obtain comparative results I likewise experimented on water from "Jones Falls," that now used by this city. They were covered over with paper so as not to exclude the air entirely, and allowed to remain undisturbed for a week, at the end of which time both waters had become slightly turbid and the lead in each was covered in some parts with a thin white film.

After acidulating the solutions with hydrochloric acid, a current of sulphuretted hydrogen was passed through each separately.

"Pump water."—No. 1. Lead, alone, very slight precipitate of the sulphid. No. 2. Lead and brass, copious precipitate.

Jones Falls.—No. 1. Lead, alone, no precipitate. No. 2. Lead and brass, copious precipitate.

I evaporated twelve ounces of each down to two, and a qualitative analysis gave the following constituents.

"Pump water."	Jones Falls.
Hydrochloric acid.	Carbonic acid, free and in combination.
Sulphuric acid.	Sulphuric acid.
Magnesia.	Hydrochloric acid.
Lime.	Lime.
Soda.	Magnesia.
Iron, (perox.)	Soda.
Reaction neutral.	Iron, (perox.)
	Reaction, slightly acid.

Judging from the quantity of the sulphuric acid precipitated from the well water by nitrate of baryta, I should infer that there existed a sufficient amount of sulphates to have protected the lead under ordinary circumstances. I have never been able to detect a trace of lead in "Jones Falls' water, nor am I aware of any bad effects ever resulting to the city from the use of lead pipe; nevertheless it has been just proved by

experiment that it will act on lead when united with brass, and placed under the necessary conditions.

The only method which I think will counteract this galvanic action, is to coat the surfaces with some substance which will entirely prevent the water from coming in contact with the pipe at the junction.

7. *Crystallization of Glass.*—Some interesting experiments on this subject have been made by M. Leydolt, in the course of his investigations upon the crystallization of the silicates. He had examined agate by subjecting it to the dissolving action of fluohydric acid, and obtained a surface with *projecting crystals* of quartz, that were left untouched by the acid. On subjecting glass in the same manner, he was surpised to see that it was far from homogeneous in its texture. All the kinds of glass examined contain more or less perfectly distinct crystals, regular and transparent, encased in an amorphous base. The crystals were brought out by exposing it to the vapors of fluohydric acid (obtained from fluor spar and sulphuric acid) and vapor of water, and arresting it when the crystals appear; the amorphous part is a little the most soluble in the acid.

M. Leydolt observes also that some natural crystals pure and transparent and apparently homogeneous, present similar deficiency in homogeneity, with the glass; and he has the subject under further examination.

8. *Analyses of Snow and Rain water;* by M. Eugene Marchand.—The snow and rain analyzed fell at Fécamp (France) in the months of March and April, 1850. A kilogramme of water contained

	Snow.	Rain.
Sulphuric acid, free or combined,	*doubtful*	*sensible proportions.*
Chlorid of potassium,	*doubtful*	*trace*
Chlorid of sodium,	0·017037 gr.	0·01143 gr.
Chlorid of magnesium,	*trace*	*trace*
Alkaline iodids and bromids,	*trace*	*trace*
Bicarbonate of ammonia,	0·001290	0·00174
Nitrate of ammonia,	0·001447	0·00189
Anhydrous sulphate of soda,	0·015627	0·01007
Sulphate of magnesia,	*trace*	*trace*
Sulphate of lime,	0·000877	0·00087
Animalized organic matter containing some iron and calcium,	0·023846	0·02486
Pure water,	999·959876	999·94914
	1000·000000	1000·00000

The organic matter of the snow deprived of fuliginous matters afforded oxyd of calcium 0·008116 grammes, peroxyd of iron 0·000450, organic matter 0·015280 = 0·023846.

9. *Titanium and Zirconia in Mineral Waters,* (L'Institut, No. 964.)—Dr. Mazade of Valance states that he has detected in the mineral waters of Neyrac (Ardèche), both titanium and zirconia. He had previously announced his having found in the same waters, molybdenum, tin, tungsten, tantalum, cerium, yttrium, glucinum, nickel and cobalt.

II. Mineralogy and Geology.

1. Mineralogical Notices, No. IV.

(a.) On General Characters of Minerals and Crystals.

On Crystallization and Amorphism; by Prof. Dr. M. L. Frankenheim, (J. f. pr. Chem., liv, 430.)—Frankenheim reviews the subject of crystalline structure and amorphism at considerable length, and arrives at the conclusion that although the structure of the intimate particles of so-called amorphous substances is not actually proved to be *crystalline* by observation, it is still true that all the properties of substances so-called are perfectly consistent with such a structure.

Delafosse on a relation between the crystalline form and atomic constitution of certain minerals, (Ann. des Mines, [4], xix, 3,) *reviewed with objections;* by C. Marignac, (Bib. Univ. de Genève, May, 1851, xvii, 33.)

On Lettering figures of Crystals; by James D. Dana, (This Jour., xiii, 399, xiv, 180.)

On Pseudomorphous minerals; by Prof. Sillem, (Leonh. u. Bronn's Jahrb., 1851, 385.)—The pseudomorphous forms described in this paper are

Pseudomorphs.	Forms imitated.
Native copper,	Red copper ore.
Silver glance,	Red silver ore.
Malachite,	Red copper ore.
Azurite,	" " "
Copper pyrites,	Fahlerz.
Copper glance,	Copper pyrites.
Horn silver,	Silver.
Brown iron ore,	Red iron ore.
Wad,	Pyrolusite.
Gypsum,	Calc spar.
Bitter spar,	" "
Kaolin,	Leucite, Sodalite.
Mica,	Wernerite.
Talc,	Kyanite.
Soapstone,	Tourmaline, Actinolite, Scapolite, Kyanite, Staurotide.
Galena,	Pyromorphite.
White lead ore,	Galena.
Red and brown iron ore,	Pyrites, Specular iron, Sphærosiderite.
Brown iron ore,	Marcasite, Calcite, Beryl.
Scheelite,	Wolfram.
Malachite,	Copper pyrites, Fahlerz, Calcite.
Electric calamine,	Blende, Psilomelane, Fluor spar.
Calamine,	" "
Calcite,	Feldspar, Pyrope, Garnet.
Quartz,	Fluor spar, Calcite, Wolfram, Augite, Carbonate of lead, Corundum, Stilbite.
Chlorite,	Calcite, Magnetic iron, Brown iron ore.
Galena,	Calcite.
Specular iron,	Calcite.
Marcasite,	Stephanite.
Spherosiderite,	Calcite.
Pyrites,	Marcasite.
Pinite,	Hornblende.
Antimony blende,	Antimonite.
Magnetic iron,	Actinolite.
Green earth,	Prehnite.
Talc,	Actinolite.

On Artificial Apatite and Topaz; by A. Daubrée, (Compt. Rend., xxxii, 625.)

(b.) New Species.

On Paisbergite, and Stratopeite, two new minerals; by Igelström, (J. f. pr. Chem., liv, 190, from Oefv. of. Vet. Akad. Förh., 1851, No. 5, p. 143).—*Paisbergite* is from Pajsberg's iron mine in Philipstadt,

and is a variety of rhodonite. It is described as transparent. Composition:

	Si	Mn	Fe	Ca	Mg	
	46·46	41·88	3·31	8·13	0·91	=100·69
Ox.	24·14	9·40	0·73	2·31	0·35	

Hence the formula $(\dot{M}n, \dot{F}e, \dot{C}a)^6\ \ddot{S}i^2$.

Stratopeite occurs in the same iron mine. It is pitch-black, and opaque in masses, and brown or brownish red in thin splinters. Amorphous; fracture flat conchoidal; streak brown; easily scratched with a knife blade; G.=2·64. B. B. fuses to a black translucent globule. With borax on platinum or with soda, a strong manganese reaction. With muriatic acid dissolves, giving out much chlorine and leaving a silica skeleton. Composition:

	Si	Mn	Fe	Mg	H	
	35·43	32·41	10·27	8·04	13·75	
Ox.	18·41	9·83	3·08	3·16	12·22	

This affords the formula $\dot{M}g^3\ \ddot{S}i^2 + 4(\dot{M}n, \dot{F}e)\ \ddot{S}i + 12\dot{H}$.

Stratopeite approaches most nearly *neotokite*, whose formula is

$$\dot{M}g\ \ddot{S}i + 4(\dot{M}n + \dot{F}e)\ \ddot{S}i + 8\dot{H},$$

and specific gravity 2·70. A mineral from Wittinge in Finland, called *wittingite* is also related to it, its formula being $2(\dot{F}e + 9\dot{M}n)\ \ddot{S}i + 3\dot{H}$, and specific gravity 2·71—2·76.

Chrismatine, a new mineral resin; GERMAR, (Deutsche Geol. Zeits., i, 40, and Leonh. u. Bronn's N. Jahrb., 1851, 353.)—This resin occurs in a red argillaceous sandstone of the coal formation at Wettin near Halle. Color oil-green to yellowish; translucent to semi-translucent; shining. Unchanged at 16 to 20° R., but softens at 10 to 12° R. Burns with flame, without smell.

Stanniferous pyrites or *Ballesterosite.*—This mineral, from Galicia, described by Schulz and Paillette, (Bull. Geol. de France, vii, 21,) is a pyrites in cubes containing traces of zinc and tin. It was named after Lopez Ballesteros. G.=4·75—4·90.

Chalcodite; C. U. SHEPARD, (from Shepard's Min. 3d edit., p. 153.) —H.=1·0—1·5. In globules, stellar groups and thin scales, or granular. Blackish green, to yellowish brown, with a bronze lustre. Form, rhombohedral? The columnar individuals possess one very distinct cleavage, upon which the lustre is pearly and semi-metallic. Streak corresponds to the color, though paler. Translucent. Sectile. Laminæ very flexible. Yields water abundantly in a closed tube; and the darker varieties change to brown. B. B. on charcoal, fuses to a black glass, which is magnetic. It disappears with rapid effervescence in borax, affording a glass deeply stained with iron. Not acted upon sensibly by cold acids; but dissolves easily, in hot hydrochloric acid, with separation of silica. It appears to be a hydrated silicate of protoxyd of iron and magnesia; containing, in the light brown varieties, an intermixture of perox. iron. Found with red iron ore, at the Sterling iron mine, in Antwerp, Jefferson county, N.Y.; and is named from *χαλκώδης, like brass*, from its bronze-like lustre.

[The mineral externally resembles cacoxene, to which species it was formerly referred. An analysis of it is much needed.]

Xanthosiderite, a new mineral from Thüringer Wald; E. E. SCHMID, (Pogg. Ann., lxxxiv, 495.)—The xanthosiderite is found with

manganese ore at Ilmenau. It occurs in fine needles united into concentric columnar stellate individuals. H.=2·5; color golden yellowish-brown to brownish-red, the former silky, the latter greasy in lustre. On gently heating gives out water and becomes darker in color, and with a continued heat, the color becomes reddish brown. B. B. acts as hydrated oxyd of iron. With concentrated muriatic acid a brown solution, containing flocks of gelatinized silica. Composition :—

	$\dot{S}i$	$\dot{F}e$	$\dot{M}n$	$\dot{A}l$	$\dot{H}$	
1. Yellow	2·51	74·96	1·82	1·32	15·67	96·28
2. Brown	5·02	75·00	1·33	1·51	14·10	96·96

The loss is due to undetermined carbonate of lime, magnesia, alkalies, antimony, lead, or bismuth, present as impurities. The formula deduced is $\dot{F}e\dot{H}^2$.

On Carrollite, a new cobalt mineral; by Wm. L. Faber.—This Journal, xiii, 418.

Two new minerals from Orange Co., N. Y., Dimagnetite and Jenkinsite; by Prof. C. U. Shepard.—This Jour., xiii, 392.

Description of two new minerals, and a new Earth; by D. D. Owen, M.D.—Jour. Acad. Nat. Sci. Philad., vol. ii, part 2, p. 179, 1852, and this Jour. xiii, 420.

On Remingtonite, a new cobalt mineral; by J. C. Booth.—This Journal, xiv, 48.

New Species by Prof. Meneghini, *of Pisa, with analyses by Prof.* Bechi.—This Journal, xiv, 60. Includes the new species, meneghinite, picranalcime, picrothomsonite, portite, sloanite, schneiderite, savite.

(c.) *Described Species.*

Red Sapphire in New Jersey.—This Journal, xiii, 116.

Anhydrite and Sulphate of Potash (*Glaserite.*)—The crystals of anhydrite, according to Hausmann (Pogg. Ann. lxxxiii, 572) afford a prism having the angle 105° 6′, which is near the angle of anglesite. A prism also in sulphate of potash has the angle 106° 46′. The following comparisons of several sulphates are presented in this paper.

	Atomic volume.	Axial ratio.	Prism ∞	Prism $1\text{-}\breve{\infty}$	Prism $1\text{-}\bar{\infty}$
$\dot{K}\ddot{S}$	412·23	0·7431 : 1 : 0·5717	120° 29′	106° 46′	75° 8′
$\dot{N}a\ddot{S}$	350·18	0·7494 : 1 : 0·5918	118 46	106 18	76 34
$\dot{B}a\ddot{S}$	329·37	0·7659 : 1 : 0·6234	116 22	105 6	78 18
$\dot{P}b\ddot{S}$	300·75	0·7686 : 1 : 0·6084	117 20	104 55	76 49
$\dot{S}r\ddot{S}$	293·47	0·7817 : 1 : 0·6181	117 10	103 58	76 2
$\dot{C}a\ddot{S}$	289·99	0·7636 : 1 : 0·6531	113 42	105 16	81 6

The author compares also the sulphates and carbonates, in the following table.

	Atomic volume.	Diff. of at. volume.	Prism ∞	Prism $1\text{-}\breve{\infty}$	Prism $1\text{-}\bar{\infty}$
$\dot{B}a\ddot{S}$	329·37	0·139	116° 7′	106° 54′	78° 18′
$\dot{B}a\ddot{C}$	286·65		118 30	105 6	77 30
$\dot{S}r\ddot{S}$	293·47	0·139	117 10	103 58	76 2
$\dot{S}r\ddot{C}$	255·33		118 19	108 12	80 12
$\dot{P}b\ddot{S}$	300·75	0·149	117 20	104 55	76 49
$\dot{P}b\ddot{C}$	258·9		117 13	108 16	80 20
$\dot{C}a\ddot{S}$	289·99	0·316	113 42	105 16	81 6
$\dot{C}a\ddot{C}$	210·94		116 16	108 27	81 33

Heavy Spar.—Limpid crystals are mentioned by Mr. F. B. Hough, as occurring at the iron mines in Rossie, St. Lawrence Co., N. Y.—5th Rep. in Cab. Nat. Hist. N. Y., 1852, p. 43.

Heavy Spar of Nutfield, near Bletchingly in Surrey.—Crystals occur, according to Prof. E. J. Chapman, in the fuller's earth pits in the greensand formation. They are tabular in form, with the basal plane (0P) predominating. Description in Naumann's system (as modified in the last volume of this Journal) 0, ∞-$\breve{\infty}$, ∞, 1-$\breve{\infty}$, 1-$\breve{\infty}$, 1.—*Phil. Mag.* [4], iii, 141.

Carbonate of Strontian, in Oneida Co., N. Y.—This Jour., xiii, 264.

Chiolite.—An analysis of the chodneffite by M. Durnev, made under the direction of Jevreinov, affords, as published by Kokscharov (Pogg. Ann. lxxxiii, 588)—

Al	Na	Fl	Ca	Fe and Mn
13·41	32·31	53·48	0·25	0·55 = 100

which gives the formula $3Na\,Fl + Al^2\,Fl^3$, or that of cryolite. The specific gravity of the Russian cryolite, according to Durnev, is 2·95, according to Kokscharov 2·962. Transparent colorless crystals of chiolite gave Kokscharov the specific gravity 2·67; or the mass in powder 2·90. A crystal one millimeter in diameter had the form of a square octahedron; angle of the pyramidal edges 107° 32′ (mean of 18 trials); of the basal, 113° 25′—113° 30′, giving the axial ratio 1·077 : 1 : 1. In one crystal, were two additional planes. There is no cleavage in chiolite, though so stated by Auerbach and Hermann; the angle they obtained, 114°, is an angle between two faces of a crystal. In one crystal there were three planes in the same zone, which gave (calling them x, y, z), $x : y = 113° 20′$; $y : z = 135° 45′$; $x : z = 69° 10′$.

On the classification of the Silicates and their allied compounds; by Prof. E. J. Chapman, (Phil. Mag. [4], iii, 270.)—Our limited space prevents our citing this paper, which hardly admits of condensation. The classification is based upon a crystallographic as well as chemical view of substances. We only question whether the former is not allowed too much weight: whether there are not striking differences, for example, in the chemical relations of quartz and beryl, which would lead one who viewed the elements and their compounds in their widest relations, to hesitate with regard to placing them in a common group. The subject is acknowledged to be one of great difficulty.

Identity of Williamsite and Serpentine.—Hermann has analyzed the williamsite of Shepard, and points out its identity with serpentine. He obtained (J. f. pr. Chem. liii, 31)—

	$\ddot{S}i$	$\ddot{A}l$	$\dot{F}e$	$\dot{N}i$	$\dot{M}g$	$\ddot{H}$	
	44·50	0·75	1·39	0·90	39·71	12·75 = 100	G. = 2·60
Oxygen	23·09	——	0·30	0·19	15·80	11·29	

The oxygen ratio afforded, for the water, protoxyds and silica is 2·07 : 3 : 4·24, or nearly 2 : 3 : 4. [See for another analysis of williamsite by Mr. Brush, Dana's Mineralogy, 3d edit., p. 692, where the conclusion is stated that the mineral is an impure serpentine. Mr. Brush obtained 3·35 p. c. of alumina.]

Soapstone from Südermannland.—Analysis by BAHR, (J. f. pr. Chem. liii, 313)—

	$\ddot{S}i$	$\dot{A}l$	$\dot{M}g$	$\dot{F}e$	$\dot{M}n$	$\dot{H}$
	61·78	0·84	30·65	2·93	1·40	2·18=99·75
Oxygen	32·05	0·39	11·66	0·65	0·29	—

Oxygen ratio 1 : 3 and formula $\dot{M}g\ddot{S}i$. Gray, massive, and without a trace of crystallization. Resembles meerschaum, but somewhat harder. Occurs in disseminated grains or massive in iron ore. Whitens when heated, and very slowly fuses with soda to a globule greenish while hot, and brown when cold. Some manganese reaction.

Note on Clinochlore, a mineral of the chlorite family; by W. P. BLAKE.—This Journal, xiii, 116; analysis of the same, by W. J. CRAW, ibid., 222.

Loganite of T. S. HUNT.—The hardness of this mineral, as stated by Mr. Hunt in his paper, (Phil. Mag. [4], ii, 65,) is 3, and the specific gravity 2·60 to 2·64.

[A small, imperfect crystal placed in the writer's hands by Mr. Hunt, presents two prismatic planes of nearly or quite similar lustre, though almost dull, and not smooth, the mutual inclination of which was found to be approximately 126°. Another specimen afforded two cleavages apparently alike, with the angle between them of 123° to 124°. These angles are not far from the angle of hornblende.—J. D. D.]

On the Optical characters of Micas; by H. SENARMONT, (Ann. de Ch. et de Phys. [3], xxxiv, 171. See this Journal, xiii, p. 409.)—M. Senarmont shows that in twin crystals of mica, the component crystals have a common cleavage, instead of forming an oblique angle with one another, as with twins of oblique crystals, and hence concludes that the form in all instances is a right and not an oblique prism, and that consequently there is in fact no *oblique* mica. Polarization has enabled him to detect such twins when not otherwise distinguishable. The following are the results of his measurements; omitting only, in most instances, those observations which were made on micas of *unknown* locality.

(1.) *Micas whose optical axes are situated in the diametral plane of the longer diagonal.*

	Appar. Incl.
1. Odontchelon, Daouria; gangue dolomite and diopside; brown; cryst.	1– 2°
2. Loc. —— ? Hexagonal; transparent; brown, a little greenish,	1– 2°
3. Loc. —— ? Hexag.; transparent; clear brown,	1– 2°
4. Loc. —— ? Hexag.; transparent; copper-colored,	3– 4°
5. Ceylon. Hexag.; transparent; clear green, nearly colorless,	3– 4°
6. Philadelphia. Transparent; clear olive-green,	57–58°
7. Siberia, in white quartz. Silvery, imperfectly trp.,	57–58°
8. Zillerthal, in albite. Silvery, imperf. transparent,	58–59°
9. Arendal, in a feldspathic rock. Transparent; pale,	58–59°
10. Loc. —— ? Transparent; gray, rhombs,	58–59°
11. Loc. —— ? Hexag.; { outer parts grayish brown, central parts colorless,	58–59° / 67°
12. Loc. —— ? Transparent; clear brown,	58–59°
13. Couzerans ? Silvery, greenish-grey, with concave surface of cleavage,	60°
14. St. Gothard, in quartzose gneiss; hexag.; silvery; clear gray,	60°
16. Miask. Transparent; clear olive-green,	62–63°
18. Ekatherinenburg. Transparent; clear pale rose,	63–64°
21. Schetank. Imperfectly transparent; rose-colored,	67°
23. Brittany. Transparent, rhombic octahedrons; blonde,	68°

	Appar. Incl.
24. Kimito, Finland. Rhombic octahedrons; transparent; clear blonde,	67–68°
25. Finland. Crystals, silvery; grayish green,	67–68°
27. Aberdeen. Transparent; blonde,	68°
28. Ekatherinenberg. Rhombic prisms in feldspar; cryst.; trp.; nearly blonde,	69–70°
29. Loc. ——? Colorless; but affords { a central region, / an outer region,	70° / 60°
32. American, probably; Lepidolite or rose mica,	74–76°
33. Alençon. Hexag.; transparent; grayish blonde,	76–77°

(2.) *Micas with the optical axes in the diametral plane of the shorter diagonal.*

34. Lake Baikal. Hexag.; deep brown; transparent,	1°
35, 36, 37, 38—micas of unknown locality,	1– 4°
39. Loc. ——? Hexag.; deep bottle green,	15°
40. Saxony. Hexag.; silvery, clear gray; transp., macled,	44°
42. Zinnwald, with tin ore. Hexag.; silvery, greenish blonde by trp.,	46–47°
43. Loc. ——? Hexag.; transparent; colorless,	50°
44. Lepidolite; rhombic,	55°
46. Piedmont. Rhombic; silvery reflection; grayish green by trp.,	63°
48. St. Féréol, near Brives. Transparent; olive-green,	65°
49. Milan. Hexag.; greenish-white; silvery; unctuous, not elastic,	65°
51. Fossum, Norway. Hexag.; clear olive-green,	66°
52. Scotland. Brown; in large thick crystals,	68°
54. Tarascon (Ariége). Rhombic; transparent; colorless,	69°
55. Ural, in graphic granite; octahedrons in quartz; silv. lustre; col. blonde,	72°
56. Utö. Rhombs; lustre silvery; yellowish blonde by trp.,	72–73°

On examining different micas pressed between two plates of glass, and subjecting them to changes of temperature, there was no perceptible change in the optical axes.

On Mica and Cordierite, especially upon Masonite, Chloritoid, Pearl mica, Kämmererite, Rhodochrome, Baltimorite and Chrome-chlorite; by R. Hermann, (J. f. pr. Chem. liii, 1.)—This paper contains general observations on the mica family of minerals, presenting a view of their composition and adding some new analyses. According to the hypothesis of the author, *phlogopite*, with Meitzendorff's formula, and *muscovite*, constitute, either separately or by a combination of the compounds in different proportions, the ordinary micas. Thus the mica of Sala, analyzed by Svanberg, is said to consist of 12 of the former to 1 of the latter ($12a+1b$), ordinary magnesian mica of $6a+b$; lepidomelane of $a+2b$. Other groups explained in a similar manner, each with its own relation of a and b, are the Lepidolite group, the Pyrophyllite group, the Margarite group. The Pyrophyllite group includes Gilbertite, Talcite, Damourite, Pyrophyllite, Agalmatolite; and the Margarite group includes Seybertite, Xanthophyllite, Brandisite (Disterrite) Chloritoid, Masonite, Diphanite, Margarite, Emerylite, Corundellite, Euphyllite. The following are analyses by Hermann of species of this group.

	Si	Al	Fe	Fe	Mg	H	
Chloritoid,*	24·54	30·72	17·28	17·30	3·75	6·38	—G.=3·52
Oxygen	12·71	14·33	5·18	3·84	1·47	5·60	
Masonite,	32·68	26·38	18·95	16·17	1·32	4·50	G.=3·46
Oxygen	16·96	12·28	5·67	3·57	0·51	4·00	
Margarite,	32·46	49·18	1·34	Ca 7·42	3·21	4·93,	K 0·05, Na 1·71=100·30, G.=2·99
Oxygen	16·81	22·96	0·40	2·12	1·27	4·35	0·01 0·43

* From Katherinenberg.

[M. Hermann cites the analyses of emerylite, corundellite and euphyllite, but had not seen the corrected results, as published in the writer's Mineralogy, 3d edit., pp. 362, 689, and this Journal, [2], x, 116, where other analyses are given, and corundellite is shown to be emerylite. There are also new analyses of emerylite by J. Lawrence Smith in this Journal, xi, 60. The analysis of margarite by Hermann renders it altogether probable that *emerylite and margarite are identical.*— J. D. D.]

The chlorite group includes Baltimorite, Chrome-chlorite, Kämmererite, Rhodochrome, Chlorite, Steatite, Thuringite and Cronstedite. The following are new analyses of species of this group:—

	Si	Al	Cr	Fe	Mg	H	
Baltimorite,	33·26	7·23	4·34	2·89	38·56	12·44	C 1·30=100·02
Oxygen	17·23	3·36	1·28	0·62	15·32	11·02	
Chrome-chlorite, Texas, Pa.	31·82	15·10	0·90	Fe 4·06	35·24	12·75,	Ni 0·25=100·12
Oxygen	16·50	7·05	0·26	1·21	13·70	11·29	0·05
Kämmererite, L. Itkul,	30·58	15·94	4·99	Fe 3·32	33·45	12·05=100·33. G=2·62	
Oxygen	15·88	7·42	1·49	0·73	11·48	10·66	
Rhodochrome, L. Itkul,	34·64	10·50	5·50	Fe 2·00	35·47	12·03=100·14. G=2·65	
Oxygen	17·95	4·90	1·63	0·60	14·08	10·61	

The chrome-chlorite of Texas, Pa., has a violet-blue to reddish color; H.=2·5; G.=2·63; lustre pearly. Texture micaceous or foliated like talc, and also somewhat plumose. In a glass tube yields water, with reaction of fluorine and chrome. Wholly dissolved in concentrated sulphuric acid, with a separation of the silica, producing a green solution.

Iron-Natrolite; Dr. C. Bergemann, (Pogg. Ann. lxxxiv, 491.)—Along with the brevicite of Brevig occurs a dull green mineral, partly semi-crystalline in large plates and partly in perfect prismatic crystals, having the form of natrolite, with a perfect diagonal cleavage. Streak or powder light green; in thin splinters opaque; H.=5; G.=2·353. B. B. on charcoal infusible, but becomes brownish-black; with the fluxes fuses and gives an iron-reaction; with borax, a yellowish glass; with salt of phosphorus a green glass, which is colorless on cooling. In a tube affords water and does not decrepitate. Easily dissolved in acids (e. g. muriatic and oxalic) and gelatinizes, even after heating. Composition:—

Si	Al	Fe	Fe	Na & little K	Mn	H
46·537	18·944	7·486	2·402	14·042	0·550	9·367=99·328

A Sodalite-like mineral; ibid.—Bore has examined a sodalite of a lavender-blue color from the island Lamo near Brevig. There is also at Brevig another related mineral, occurring in green feldspar with greenish elæolite. Color of the mineral dull greenish; streak and powder white; H.=5; G.=2·302; translucent; lustre vitreous. Occurs in large crystalline masses, having a cleavage which seems to be rhombohedral. Heated in a tube yields no vapor. B. B. on charcoal becomes white, and after long blowing the edges become fused without intumescence. With soda fuses very slowly to a white enamel; with borax or salt of phosphorus, forms a glass with much difficulty, which is colorless. In acids easily decomposed, forming a jelly; after heating also dissolves readily. Composition:—

$\ddot{S}i$	$\dot{A}l$	$\dot{N}a$	$\dot{C}l$	$\dot{P}$	$\dot{C}a$ & $\dot{F}e$	
46·028	23·972	21·483	7·431	0·857	*trace*	=99·771

Oxygen ratio in the silica, alumina and soda is 6 : 3 : 1, whence the formula is $\dot{N}a\ddot{S}i + \dot{A}l\ddot{S}i + \dot{C}l\,\dot{N}a$.

Nepheline, variety Sommite or Davyne.—A. Scacchi gives the following as the observed inclination of the basal plane on planes of the series of hexagonal pyramids, $\frac{1}{5}$, $\frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{2}$, 1, 2, 3,—on $\frac{1}{5}$ 158° 52′, on $\frac{1}{4}$ 154° 15½′, on $\frac{1}{3}$ 147° 18′, on $\frac{1}{2}$ 136°, on 1 117° 22′, on 2 104° 35′, on 3 99° 45′. Cleavage lateral, distinct. The crystal occurred in a geode in limestone on Mt. Somma with crystals of sodalite. (Pogg. Ann. 1852, Ergänz. iii, Stuck 3, 478.)

Mizzonite and Meionite, varieties of Scapolite.—M. Scacchi also gives figures illustrating the mizzonite and meionite of Mt. Somma. In mizzonite the adjacent planes in the same pyramid have the angle 135° 56′, (see figures of scapolite,) in meionite 136° 11′; adjacent planes in opposite pyramids in mizzonite 64° 08′, in meionite 63° 40′. The terminal plane of the prism is often found in crystals of mizzonite and seldom in meionite. The mizzonite, before the blowpipe does not intumesce as much as the meionite, and is not so easily soluble in acids. The mizzonite often occurs in pearly acicular crystals.—(Ibid. p. 478.)

On Scapolite; by R. Hermann, (J. f. pr. Chem. liv, 410).—The following new analyses are given in this paper.

	$\ddot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{F}e$	$\dot{M}n$	$\dot{C}a$	$\dot{N}a$	$\dot{K}$	$\dot{C}$	
1. Strogan'wite	40·58	28·57	0·89	—	*trace*	20·20	3·50	—	6·40	=100·14
Ox.	21·08	19·34	0·26	—	—	5·74	0·89	—	4·65	
2. Scapolite,	45·99	28·80	—	2·25	0·25	13·83	2·11	0·70	4·06	$\dot{H}$0·30=98·29
Ox.	23·87	13·45	—	0·50	0·05	3·96	0·53	0·11	2·93	
3. Ekebergite,	49·49	26·06	2·65 $\dot{M}g$.	0·36	0·25	12·89	4·50	0·80	3·00	$\dot{L}i$ *tr.*=100 00
Ox.	25·69	12·14	0·78	0·14	0·05	3·69	1·15	0·14	2·16	
4. Scapolite,	52·94	27·64	— $\dot{F}e$	0·30	0·25	9·10	6·89	0·54	1·50	$\dot{H}$0·66=99·72
Ox.	27·50	12·93	—	0·06	0·05	2·60	1·76	0·08	1·08	
5. Red Scap.	50·16	28·44 $\dot{M}g$	0·76	0·12	0·14	13·12	1·42	0·91	2·94	$\dot{H}$0·8, $\dot{L}i$ *tr'ce*
Ox.	26·00	13·28	0·30	0·02	0·03	3·67	0·36	0·15	2·12	[=98·81
6. White Scap.	54·64	23·32 "	0·20	1·00	0·14	9·05	8·44	1·24	2·50,	$\dot{L}i$ *tr.*=100·53

No. 2, from Diana, N. Y.; No. 3, from Hesselkulla, massive, oil gray; No. 4, from Gulsjo, white; No. 5 and 6, from Bolton, Mass.

Sp. gr. of 1, 2·79; of 2, 2·74; of 3, 2·80; of 4, 2·69; of 5, 2·70; of 6, 2·66. The Stroganowite is identical with Hartwell's Pargas Scapolite.

M. Hermann considers the carbonic acid as replacing silica, while it is regarded by others, with more probability, an impurity.

M. Hermann makes 4 groups of species or varieties in the scapolite family, the distinctions in which depend not on the oxygen proportions, but upon the hypothetical "heteromerous molecules" assumed as existing in the mineral. The groups are—

(1.) *Gehlenite group.*—Gehlenite $=\dot{R}^3\ddot{S}i + \dot{A}l\ddot{S}i$.

(2.) *Humboldtilite group.*—The "heteromerous molecules" are, *a*, having the oxygen ratio $1 : \frac{1}{2} : 1\frac{2}{3}$; and *b*, with the ratio 1 : 2 : 3. Humboldtilite $=(a)$; Sarcolite $=(a+b)$; Atheriastite $=(a+b)+8\dot{H}$.

(3.) *Dipyre group.*—The "heteromerous molecules" are, *a*, having the oxygen ratio 1 : 2 : 4, *b*, with the ratio 1 : 2 : 6. Stroganowite $=(a)$; Dipyre $=b$; another variety of dipyre $=(6a+b)$; a third $(3a+b)$.

(4.) *Wernerite group.*—The "heteromerous molecules" are *a*, having the oxygen ratio 1 : 2 : 3, and *b*, with the ratio 1 : 3 : 6. Anhydrous Meionite $=(a)$; Edingtonite $(a)+12\dot{H}$; Wernerite, 1st var. $=(a+b)$; 2nd var. $(a+2b)$; 3d var. $(a+6b)$; 4th, $(a+12b)$. Wernerite $=(b)$.

[This mode of viewing the composition cannot claim for itself simplicity. The various compounds of the scapolite group are isomorphous, from their atomic volume, and this splitting up of the formulas into hypothetical parts affords little satisfaction to theory. The various attempts to write out formulas by different theorists are so diverse in their results, that we may question whether, in the case of the silicates for example, truth and the highest generalizations are not the best displayed by simply giving the oxygen ratios. We cannot suppose such compound molecules actually to have existence in the above $(a+b)$ minerals. They are at the best, imaginary quantities for the convenience of classification.]

Mineralogical Notes by Prof. E. J. Chapman, (Phil. Mag. [4], iii, 141.

Crednerite.—Rammelsberg's formula for crednerite is $(\dot{B}a, \dot{C}u)^3\ddot{M}n^2$. Prof. Chapman remarks on the monoclinic cleavage of crednerite and the probable approximation of the angle to that of augite; and then supposing that $\ddot{S}i$ may replace $\ddot{M}n$, (the examples of which mentioned are those of manganesian garnet, spinels, vesuvian, hausmannite), he considers the above formula as of the augite type.

Helvine.—On the same supposition as to the isomorphism of $\ddot{S}i$ and $\ddot{M}n$, and also considering S and O as isomorphous, helvine is observed to fall into the formula of garnet $r+R$, or one part of protoxyd bases to one of silica or peroxyd bases, stated by Mr. Chapman to be "equal atoms of base and acid." The formula of helvine,

$$(\dot{B}e, \dot{F}e)\,\ddot{S}i + 2\dot{M}n\,\ddot{S}i + Mn\,S,$$

becomes on the above hypothesis, 3 atoms of $(\dot{M}n, Mn\ S)$ and 3 atoms of $\ddot{R}, \ddot{S}i$, equivalent to the oxygen ratio of 1 : 3. [The oxygen ratio in garnet, for the protoxyds, peroxyds and silica is 1 : 1 : 2; which gives the ratio of 1 : 1 for the oxygen of the bases and the silica,—if we suppose that the peroxyds and protoxyds replace one another, as is shown to be true in very many cases by Gerhardt. This view appears to be better sustained as a general principle, than that of the mutual substitution of $\ddot{S}i$ and $\ddot{R}$, although instances of this last exist. In either case, the relation of helvine to garnet is made out, as stated by Mr. Chapman; for the above formula becomes thus, $\ddot{R}\ddot{S}i+(\dot{M}n, Mn\ S)^3\ddot{S}i$, which is essentially the usual formula of garnet, having the ratio 1 : 1 : 2. The identity does not require us to suppose the isomorphous relation of the peroxyds and silica.—J. D. D.]

Phenacite and Beryl.—The isomorphism as well as general resemblance in external characters of phenacite and quartz, is remarked upon by Prof. Chapman, and he observes that the common phenacite rhombohedron $=\frac{1}{2}R$ compared to the quartz form as unity. Beryl is also referred to the quartz group, and it is remarked that if glucina be looked upon as a sesquioxyd, there can be no difficulty in placing both phenacite and beryl in that group. "On the other hand, if the formula of glucina be Be O, the isomorphism of $3\dot{B}e$ and $\ddot{S}i$, and the sesquioxyd isomorphs of

the latter must be allowed. Of the other glucina compounds, chrysoberyl may be a trimetric and euclase a monoclinic quartz. With the former are associated staurolite, andalusite, topaz, &c." [If we calculate the angle of the form $\frac{1}{2}R$ for quartz, we find it 126° 52′, which is 7 or 8 degrees larger than that of the common rhombohedron of phenacite (115° 25′—116° 40′.) This appears to be at variance with the above conclusions.—J. D. D.]

Prof. Chapman applies the same principle—the isomorphism of silica and the peroxyds,—to other groups, as sphene and epidote; chlorite spar and chloritoid; wichtyne, epidote, &c.

Analysis of Caporcianite and Humboldtite; Meneghini and Bechi. This Jour., xiii, 62 and 65.

Heulandite.—This mineral, according to Mr. G. W. Fahnestock, occurs in small prismatic crystals covering the sides of fissures in a hornblende rock several miles southwest of Philadelphia. The surface is rusty from oxyd of iron, which has probably proceeded from the decomposition of the rock.

On a Garnet-like mineral from Brevig, Norway; Dr. C. Bergemann, (Pogg. Ann. lxxxiv, 485.)—This mineral occurs in black opaque crystals associated with elæolite, zircon and fluor spar at Brevig. Streak yellowish-green; H.=5·0; G.=3·880, or 3·898 after strong heating. Form like that of garnet; crystals sometimes half an inch through. B. B. in thin splinters unchanged; with soda, a silica skeleton, and the glass yellowish; with borax, a deep yellowish green glass, which does not change color on cooling; with salt of phosphorus, a yellowish-green pearl and gives the reaction of titanium. With muriatic acid, easily and wholly decomposed, without gelatinizing; after heating, still dissolved but with difficulty. Composition:—

	$\ddot{S}i$	$\dot{F}e$	$\dot{C}a$	$\dot{M}n$	$\dot{T}i$ & $\dot{Z}$	$\dot{M}g$ & $\dot{K}$
	33·355	34·598	25·804	1·807	3·071	*trace* = 99·319
Oxygen	17·30	7·66	7·32	0·44		

The mineral differs from all garnets in its infusibility and its perfect solubility in acids. It may hereafter be proved to be a partly altered mineral; but it is more probable, the author states, that it is a new variety.

Garnet from Gustafsberg with Stilbite.—Analysis by Bahr, (J. f. pr. Chem. liii, 312.)

$\ddot{S}i$	$\dot{A}l$	$\ddot{F}e$	$\dot{F}e$	$\dot{C}a$	$\dot{M}n$	$\dot{M}g$
37·80	11·18	15·66	4·97	30·28	0·13	*trace*
Oxygen 19·63	5·22	4·70	1·00	8·61	0·02	

It gives the usual formula $\dot{R}^3\ddot{S}i + \ddot{R}\ddot{S}i$. Specific gravity 3·6.

On the Composition of Epidote.—Rammelsberg, in Pogg. Ann. lxxxiv, 453, opposes the views of M. Hermann with regard to the composition of epidote, and sustains the conclusion that the oxygen ratio for the protoxyds, peroxyds and silica, is essentially 1 : 2 : 3.

Chrome Tourmalines.—The Siberian tourmalines sometimes contain a small amount of oxyd of chromium. They are in acicular groups and have a fine green color; H.=7·0, G.=3·181. Fusible.—Prof. Chapman, *Phil. Mag.* [4].

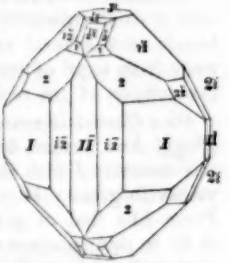
Tourmaline.—A reply to Rammelsberg on the composition of tourmaline by Hermann, is published in the Jour. f. prakt. Chem. liii, p. 280.

Emerald of New Grenada.—M. B. Lewy has examined the locality of emeralds of Muzo. The rock is a black limestone, and the mineral is accompanied with crystals of calc spar and parisite or carbonate of lanthanum. In the same deposits, M. Lewy collected an ammonite peculiar to the Neocomian series.

On the Gigantic Beryls of New Hampshire; by O. P. Hubbard. This Jour. xiii, 264.

On the angles of Eumanite; by J. E. Teschemacher.—This Jour. xiii, 117.

On Crystals of Brookite from the Ural; by N. von Kokscharov, (Verh. der Min. Ges. zu St. Pet., 1848–49).—This paper was mentioned by us in vol. xi, p. 228. We now add a figure from it, and give the angles anew. $1:1=99°\ 50'$ and $80°\ 10'$, $i\bar{2}:i\bar{2}=134°\ 21\frac{1}{2}'$, $2\breve{i}:2\breve{i}$ (over II)$=124°\ 12'$; $\frac{1}{2}\breve{i}:\frac{1}{2}\breve{i}$ (over P)$=121°\ 24\frac{1}{2}'$; $\frac{1}{4}\breve{i}:\frac{1}{4}\breve{i}$ (over P)$=148°\ 39\frac{1}{2}'$; angles of octahedron 1, $101°\ 35'$, $115°\ 43'$, $111°\ 25\frac{1}{2}'$; octahedron 2, $87°\ 12'$, $104°\ 54'$, $142°\ 21'$; octahedron $\frac{1}{2}$, $126°\ 12'$, $135°\ 14'$, $72°\ 30\frac{1}{2}'$; $1\text{-}\bar{2}$, $135°\ 37'$, $101°\ 3'$, $95°\ 22\frac{1}{2}'$; $2\text{-}\bar{2}$, $124°\ 36'$, $77°\ 1\frac{1}{2}'$, $131°\ 3'$.



Zircon.—Hyacinth occurs on the North fork of the American river, California, in almost microscopic crystals: form a square prism, with the diagonal prism, and often with the faces of an octahedron and a zirconoid, sometimes with also a basal plane. Colorless or with a smoky tinge.

Chromic Iron occurs at the same locality, in rounded grains, sometimes showing octahedral faces. Also *ilmenite* in iron-black grains.—*F. A. Genth*, Proc. Acad. Nat. Sci. Philad. vi, 113.

Pyrochlore and Garnet of the Urals.—Kokscharov has described and figured octahedral crystals of pyrochlore (Vesh. Min. Ges. St. Pet., 1848,) in which the angles are truncated, and two additional planes 2-2 and 3-3 replace the edges between the truncating plane ($\infty\text{-}1$, dodecahedron) and the octahedral faces. A garnet is also given in his paper which has the obtuse angles of the dodecahedron replaced by 6 planes, $3(2O)$ inclined on the faces, and $3(\frac{1}{3}O\frac{4}{3})$ on the edges intermediate.

Xenotime in Georgia and North Carolina.—This Jour. xiii, 143.

Malacone of the Ilmen Mountains.—The Ilmen malacone has been examined by M. Hermann (J. f. pr. Chem. liii, 32.) The crystals are much like those of zircon and present the faces of an octahedron $1:1:1$, and of a square prism, $\infty:1:\infty$; pyramidal angle of the octahedron about 124°. Lustre rather weak, somewhat greasy, inclining to adamantine. Lustre of surface of fracture weak and greasy. Color nut-brown. H.=1·5. G.=3·91. Composition;—

	$\dot{S}i$	$\dot{Z}r$	$\dot{F}e$	$\dot{M}n$	$\dot{H}$
	31·87	59·82	3·11	1·20	4·00
Oxygen	16·50	15·72	0·68	0·26	3·55

This gives the formula, $3\dot{Z}r\,\dot{S}i+2\dot{H}$.

White Antimony in the Province of Constantine, Algeria, (Ann. des Mines, [4], xx, 81.)—An analysis by M. E. Cumenge afforded—

Sb 62	O 17	Ḣ 15	Ḟe 1	Argillaceous gangue 3 = 98

The formula deduced is $3Sb\,O^5+2Sb\,O^3+15HO$.

There are two mines of oxyd of antimony in the Province of Constantine, one north of Ain-Bebbouch, at Sensa, and the other at Oued Hamimim, northeast of Sensa. The two yielded 1541 metric quintals of ore in 1850.

Analysis of White Antimony of Pereta, Tuscany; Meneghini and Bechi.—This Journal, xiv, 61.

Native Iron.—M. Bahr has described specimens of carbonized wood associated with bog ore from Smaoland, which afforded grains of malleable iron having a specific gravity 6·248—6·4972, and 6·6255 after hammering, and he considers it as probably a result of deposition through some electric process, and not artificial in origin. He suggests for coal containing iron in this manner, if hereafter found, the name *Sideroferite.*

On Chrome Iron and Magnetic Chrome Sand from Pennsylvania; by T. H. Garrett.—This Journal, xiv, 45.

Analyses of Braunite, Chromic Iron and Silicated Chrome, from Tuscany; Meneghini and Bechi.—This Journal, xiv, 61.

Vanadium in the iron from the Perm Smelting Works, Russia.—Schubin showed in 1839 that vanadium existed in the iron smelted at Perm. In a cupreous sandstone, in which with the help of a lens, vanadate of copper was recognized, he found on analysis 0·53 p. c. of vanadic acid. An analysis of the pig-iron afforded—

C	Va	S̈i	Cu	Fe	Al	Mg	Ca
3·03	1·99	2·51	12·64	75·97	0·89	0·78	0·95=98·76

The *black copper* obtained at the same time with the cupreous pig-iron afforded—

Carbon 0·94	Va 1·21	Cu 90·52	Fe 6·17

—J. Fritzsche, *Bull. de St. Petersb., Chem. Gaz.*, No. 218.

On Octahedral Specular Iron; by T. S. Hunt.—This Jour. xiii, 370.

Titanic Iron from Miask; E. E. Schmid, ibid. (Pogg. Ann. lxxxiv, 498.)—A large crystal of titanic iron from Miask is a broad table 150$^{mm.}$ broad and 95$^{mm.}$ thick, presenting the planes 0R, R,—½R. Cleavage basal but not perfect; H.=6; G.=4·85–4·89; streak black; very weak magnetic. Composition:—

Ti 28·05	Fe 70·7	Mn 0·7 = 99·9

agreeing closely with the analysis by Mosander.

Olivine of the Meteoric iron of Atacama; E. E. Schmid, (Pogg. Ann. lxxxiv, 501.)—Composition:—

S̈i	Ṁg	Ḟe	Ṁn Ṁn
36·92	43·16	17·21	1·81 = 99·10

affording the general formula $(\dot{M}g, \dot{F}e, \dot{M}n)^3\,\ddot{S}i$, or $5\dot{M}g^2\,\ddot{S}i+(\dot{F}e, \dot{M}n)^3\,\ddot{S}i$.

Analysis of a Nickeliferous magnetic Pyrites from Pennsylvania; by Prof. M. H. Boye.—This Jour. xiii, 219.

Manganese Ores.—The following analyses are by Bahr, (J. f. pr. Chem. liii, 308, from Oefvers. af Akad. Förh. 1850, No. 9, p. 240.)

		$\ddot{S}i$	$\ddot{A}l$	$\ddot{F}e$	$\ddot{M}n$	$\dot{C}a$	$\dot{M}g$	$\dot{H}$	
1. From Klapperud,		36·20	1·11	0·70	47·91	0·61	4·43	9·43	=100·39, *Bahr.*
	Ox.	18·79	0·53	0·21	14·54	0·17	1·71	8·38	
2. "	"	36·11	0·90	11·31	42·00	0·70	0·57	9·43	=101·03, *Svanberg.*
	Ox.	18·75	6·42	3·39	12·75	0·20	0·22	8·38	
3. "	"	34·72	1·09	10·45	42·64	0·56	0·36	9·76	=99·98, *Bahr.*
	Ox.	18·04	0·51	3·13	12·79	0·16	0·14	8·67	
4. "	"	23·69	0·61	9·14	56·21	0·50	0·39	9·51	=100·05, *B.*
	Ox.	12·30	0·29	2·74	17·04	—	—	6·45	
5. "	"	35·81	1·03	7·53	$\dot{M}n$ 46·18	0·72	1·42	9·57	=100·26, *B.*
	Ox.	17·55	0·48	2·26	10·38	0·20	0·55	8·51	
6. "	"	43·30	6·80	4·57	$\dot{M}n$ 9·88	15·96	11·90	6·13,	$\dot{C}o$ 0·39 = 98·93
	Ox.	22·48	3·18	1·37	2·22	4·54	4·61	5·45,	0·08 = 98·93
7. From Skidberg,		0·92	0·75	2·70	$\frac{\dot{M}n}{\ddot{M}n}$ 66·16	0·59	0·28,	ign. 12·07,	$\dot{B}a$ 15·34, $\dot{C}o$ 0·02, $\dot{K}$ 0·28 = 99·11

Analyses 1 to 3 give the oxygen ratio for the water, peroxyds and silica 1 : 2 : 2, and the formula $2\dot{M}n\,\ddot{S}i + 3\dot{H}$. The species resembles externally Klaproth's black silicate of manganese. Color dull lead-gray.

Analysis 4 affords the ratio 1 : $2\frac{1}{2}$: $1\frac{1}{2}$, and the formula $\dot{R}^5\,\ddot{S}i^3 + 6\dot{H}$, or, it may perhaps be written $(2\dot{M}n\,\ddot{S}i + 3\dot{H}) + (\dot{R}^3\,\ddot{S}i + 3\dot{H})$. The mineral occurs mixed with the preceding. Color pure black; fracture earthy; but little hardness. G.=3·207.

Analysis 5 may have the formula $(6Mn^3\,\ddot{S}i + \dot{H}) + \ddot{F}e\,\dot{H}^3$.

Analysis 6 affords the ratio for water, protoxyds, peroxyds and silica 1·19 : 2·51 : 1 : 4·94. The loss is probably part alkali and part protoxyd of iron, which possibly may make the ratio 1 : 3 : 1 : 5, and give the formula $(3\dot{R}^3\,\ddot{S}i + \dot{H}) + \dot{R}\,\ddot{S}i^3$. Color light yellow; massive; cleavage not distinct; fracture fine splintery; hardness small; lustre between vitreous and greasy; G.=3·320 at 15° C. It blackens in a glass tube, and fuses with intumescence on a coal to a black glassy globule. In fragments dissolves with difficulty in acids, but easily when pulverized; gives the manganese color. Not dissolved in heated muriatic acid and only imperfectly in concentrated sulphuric acid.

Analysis 7 belongs to a *psilomelane*. G.=4·254 at 15° C.; scratched with difficulty by felpspar; powder black; soluble in muriatic acid.

Placodine.—Dr. Schnabel states (Pogg. Ann. lxxxiv, 585,) that the *Placodine* of Breithaupt (Pogg. 1841, p. 631) is probably a furnace product, which has resulted from a reduction of nickel ore. Prof. G. Rose (ibid. lxxxiv, p. 589) also observes that in his system of Mineralogy, published in 1847, he remarked that placodine was probably identical with the *nickelspeise* of Wöhler, and a furnace product. Although the angles of the two do not seem to agree, still there is a general similarity in the crystals, and he found some angles the same. A new analysis of the nickelspeise has been made by H. Schlossberger, who obtained—

As	S	Ni	Cu	Co	Fe
44·72	1·82	49·45	1·16	0·81	0·45

a result agreeing well with that of Wöhler (Pogg. Ann. xxv, 302). Prof. Rose closes with the remark that a revision of the analysis of placodine is needed.

Sulphuret of Nickel in Pennsylvania.—This Journal, xiii, 117.

Erubescite and Copper Pyrites of the Espedal Copper Works, Norway; Mr. DAVID FORBES, (Jameson's Edinb. Jour., l, 278.)—The erubescite has the sp. gr. 4·432, at 60° F. Composition:—

S	Cu	Fe	Mn	Si	
24·49	59·71	11·12	0·1	3·83	= 99·15

This corresponds to the formula $_7Cu\,S+Fe^3\,S^4$ = sulphur 25·23, copper 63·17, iron 11·60=100. Mr. Forbes reviews various analyses of this mineral, and concludes that the species is a compound of a protosulphuret and disulphuret of copper, with more or less of the copper replaced by iron. He thus deduces the formulæ:

$2Cu^2\,S+Cu\,S$, (corresponding to S 23·28, Cu (with Fe) 76·62=100)—for the Killarney mineral, analyzed by Phillips.

$Cu^2\,S+Cu\,S$ (corresponding to S 25·31, Cu (with Fe) 74·69), for the above ore, and that analyzed by Bodemann, Plattner and Hisinger.

$Cu^2\,S+2Cu\,S$, (corresponding to S 27·60, Cu 72·40), for the crystallized ore analyzed by Plattner.

Digenite is included under the last, it being a variety containing no iron.

The copper pyrites has the hardness 3·5, and G. (at 60° F.)=4·185. Composition obtained:—

S	Cu	Fe	Mn	Si	
33·88	32·65	32·77	*trace*	0·32	= 99·62

Analyses and descriptions of Fahlerz, Copper glance, Chalcopyrite, Erubescite, Zigueline, of Tuscany; MENEGHINI and BECHI.—This Journal, xiv, 60.

Chalcotrichite at the Perkiomen Lead mine.—This Journal, xiii, 117.

On the Galmei of Weisloch in Baden; by GUSTAV HERTH, Dr. Philos. Inaug.-dissert., 46 pp. 8vo. *Heidelberg*, 1851.

Analysis of Marmatite and oxyd of Zinc from Tuscany; MENEGHINI and BECHI.—This Journal, xiv, 60.

Note on the Lead ores of Chester Co., Pennsylvania.—This Journal, xiii, 116.

Analyses and descriptions of Galena and Feather ore of Tuscany; MENEGHINI and BECHI.—This Journal, xiv, 60.

Platinum and Iridosmine in California; Dr. F. A. GENTH, (Proc. Acad. Nat. Sci. Philad., vi, 113).—A few steel-colored rounded grains of platinum were observed among specimens of gold from the American fork, California, 30 miles from Sacramento city. *Iridosmine* from the same locality occurs in lead-colored scales. A collection of white grains from California, afforded, after separating the platinum, six-sided scales of a color between lead and tin-white, which on heating on platinum foil, gave a strong odor of Osmium, and were probably therefore the *Sisserskite* ($Ir\,Os^4$); when thus heated, the scales became iridescent and assumed yellow orange and blue colors like steel. Dr. Genth, on trying the Ural iridosmine, found that the lead-colored scales afforded the same colors; and he suggests that this may be a good test for distinguishing the *Sisserskite* from the *Newjanskite*. He adds that there are probably in nature only two distinct compounds of iridium and osmium, viz: $Ir\,Os^4$ and $Ir\,Os$; and the compound $Ir\,Os^3$ is probably a mixture of the two.

Sulphur mine in Upper Egypt.—An extensive bed of sulphur has been opened in Egypt between the village of Keneh and the Red Sea, at the strait called Bahar el Sefingue. It is soon to be worked.—Ann. des Mines [4], xviii, 541.

Sulphuret of Arsenic and Sulphur in Koordistan.—This Jour. xiv, 103.

Mineralogy of the Granular Limestone in the Gneiss of the Vosges; M. Delesse, (Ann. des Mines, [4], xx, 145.)—(1.) *Mica.*—The most prevalent mineral contained in the limestone is mica. The mica has G.=2·746; color greenish; lustre somewhat greasy; unaltered by atmospheric action. Two axes of double refraction very near one another. B. B. exfoliates and gives out a bright light, and fuses with difficulty to a white enamel. Analysis, p. 153:—

	$\ddot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{M}n$	$\dot{C}a$	$\dot{M}g$	$\dot{N}a$	$\dot{K}$	Fl	ign.
	37·54	19·80	1·61	0·10	0·70	30·32	1·00	7·17	0·22	1·51=99·97
Ox.	19·51	9·25	0·37	0·02	0·20	11·73	0·26	1·22	—	—

This gives the oxygen ratio for the protoxyds, peroxyds and silica 13·79 : 9·25 : 19·51=3 : 2 : 4, affording the formula $3\dot{R}^2\ddot{S}i+\dot{R}^2\ddot{S}i$. The optical character appears to show that the mica is a phlogopite, although differing from that species a little in composition. The formula given for phlogopite is $3\dot{R}^3\ddot{S}i+2\dot{R}\ddot{S}i$.

(2.) *Pyrosclerite?*—Occurs especially at St. Philippe. Color grayish, to bluish, nearly emerald green; lustre greasy or waxy; soft; G.=2·622. Attacked completely by muriatic acid, but without giving a jelly. B. B. fuses with difficulty to a whitish glass; a pure blue color with nitrate of cobalt. Composition, p. 157:—

	$\ddot{S}i$	$\dot{A}l$	$\ddot{C}r$	$\dot{F}e$	$\dot{M}n$	$\dot{C}a$	$\dot{M}g$ (by diff.)	$\dot{H}$
	38·39	26·54	*trace*	0·59	*trace*	0·67	22·16	11·65=100·00
Ox.	19·95	12·40	—	0·13	—	0·19	8·55	10·36

The mineral resembles serpentine, but contains much more alumina, and is more fusible. The formula afforded is $3\dot{M}g\ddot{S}i+4\dot{A}l\ddot{S}i+9\dot{H}$, or possibly $\dot{M}g^3\ddot{S}i+\dot{A}l\ddot{S}i+3\dot{H}$.

Pyroxene.—A pyroxene (sahlite) from Chippal, afforded, p. 145—

$\ddot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{M}n$	$\dot{C}a$	$\dot{M}g$ (by diff.)	ign.
54·01	1·10	4·25	*trace*	16·10	20·94	3·60=100·00

Specific gravity 3·048. Structure that of a sahlite. It is probable, Delesse suggests, that the original composition of the mineral may have been modified by a pseudomorphic process.

M. Delesse observes that the pyrallolite, of Storgard, Finland, has the angles nearly of pyroxene and differs but little in composition from the sahlite of Chippal.

The gneiss enclosing the limestone contains both feldspar (orthoclase) and oligoclase, with pyroxene and hornblende. The following analyses are given.

	$\ddot{S}i$	$\dot{A}l$	$\dot{F}e$	$\dot{C}a$	$\dot{M}g$	$\dot{N}a$	$\dot{K}$	
1. Orthoclase,	64·04	19·92	—	0·39	0·33	2·18	11·48	=98·34
2. Pyroxene,	53·42	1·38	8·53	21·72	14·95*	—	—	=100·00
3. Hornblende, gn'h-bk,	44·82	13·18	11·17	9·69	19·48*	—	ign. 1·66	=100·00

* By difference.

M. Delesse remarks on the mineral similarity of the granular limestones of the Vosges and those of the United States and other regions; pyroxene, tremolite and other varieties of hornblende, spinel, sphene, graphite, phlogopite, pyrosclerite, are common to both.

Analyses of Limestones of Herzogthums Nassau; by Dr. R. Fresenius, (J. f. pr. Chem. liv, 85 and 374.)

Hydraulic Limestome, explored near Thonon (Chablais.)—Marignac obtained as the result of two analyses—

Ca C	Mg C	Clay.	Water.
50·25	40·95	8·17	0·92 = 100·29
50·36	41·99	7·05	0·37 = 99·77

The carbonates of lime and magnesia are in the proportions of a true dolomite. The color of the rock is a deep gray, texture very fine and compact, fracture conchoidal.

On the Diorites of the Vosges; by M. Delesse, (Ann. des Mines, [4], xix, 149.)—In the course of this excellent paper, M. Delesse gives the following analyses:

	Si	Al	Fe	Mg	Ca	Na	K	ign.
1. Oligoclase, Clefcy,	66·11	19·33	0·50	0·47	1·82	8·17	2·89	0·80=100·09
2. " Visembach,	63·88	22·27	0·51	*trace*	3·45	6·66	1·21	0·70= 98·68

The name *Kersantite* is applied to the rock at Visembach. It is a crystalline rock associated with gneiss, consisting mostly of oligoclase and mica, with sometimes hornblende, while *Kersanton* consists mainly of feldspar. Plate 2, represents very beautifully the appearance of these and other rocks.

Meteoric Stone of Stannern.—This meteorite fell in numerous pieces on the 22nd of May, 1808. Rammelsberg obtained in an analysis (Pogg. Ann. lxxxiii, 591). Part soluble in hydrochloric acid 34·98 p. c. Part insoluble 65·02 p. c. Composition :—

	Si	Al	Fe	Mn	Ca	Mg	Na	K	Cr Fe	
Soluble part,	46·19	31·26	2·93	—	16·98	1·12	1·14	0·50	—	=100·12
Insoluble "	49·44	2·64	Fe 28·31	1·25	8·20	9·97	0·35	0·10	0·83	=101·09; [mean of 2 determinations.

The soluble part has nearly the oxygen ratio of *Anorthite*, and the insoluble part, that of *augite*. The composition is quite near that of the Juvenas meteorite.

Appendix.

Molybdate of Iron, a new Mineral from California; D. D. Owen, (Proc. Acad. Nat. Sci. Philad., vi, 108).—This mineral is from near Nevada city, California. It has a deep yellow color, and a fibrous or acicular structure, or is in tufted crystals. An approximate analysis afforded

Mo?	Fe	Mg	Alkali	H
40	35	2	8	15

The oxyd of molybdenum is, in all probability, molybdic acid. B. B. fuses easily, and if supported on its quartz matrix, a bluish ring is formed around the assay. With salt of phosphorus, a green bead is obtained.

[A very small fragment of this mineral was received here from Prof. Blake, and its quantitative analysis by Mr. Wm. J. Craw afforded molyb-

dic acid and oxyd of iron; but the amount was too small for any definite determinations, or even to ascertain whether the iron was in chemical combination.—J. D. D.]

Strontiano-calcite, a new species; Dr. F. A. Genth (Proc. Acad. N. Sci. Phil., vi, 114, June, 1852).—Crystallization and cleavages like calc spar: secondary form an acute rhombohedron of 65° 50′. Crystals minute; occurs in globular masses, the globules terminating in this acute rhombohedron. H=3·5. G. undetermined. Colorless and transparent or white and translucent, the former vitreous, the latter pearly in lustre. B. B. yields a brilliant light, a slightly crimson flame, and becomes caustic. The solution in acids gives a white precipitate with sulphate of lime, but not with sulphate of strontia, and it therefore contains strontia. After precipitating the strontia in a portion of the solution, the addition of oxalate of ammonia produced a precipitate of oxalate of lime. The quantity was too small for a quantitative analysis, but Dr. Genth infers that the lime and strontia are in about equal proportions.

The specimen was from Girgenti, Sicily, where it is of rare occurrence associated with celestine and sulphur.

2. *Large Deposit of Graphite.*—At St. John, N. B., near the new suspension bridge over the St. John's river, a very extensive deposit of graphite has been opened and explored to a considerable extent. The vein, or bed as it might more properly be called, is nearly vertical, and inclosed between beds of highly metamorphic schists. It is entered near the water on the face of a precipitate cliff about seventy feet high, the walls of the lode being in the main parallel to the graphite deposit. This bed has been explored by a gallery or adit level over a hundred feet, and by cross cuts at right angles to this some twenty or more feet. All these are in the graphite mass, and of course the floor and roof of the levels are of the same mineral. The quartzose walls have occasionally approached, and in some cases masses of quartz, or schist, have been included in the graphite. The course of this deposit is about northeast and southwest, or nearly in the direction of the strike of the strata of schist. The graphite is not of a very superior quality as a mass, though portions of it are quite pure. As yet no solid and perfectly homogeneous masses have been taken out. It has a foliated structure more or less highly marked. Iron pyrites is too abundantly diffused in it to admit of its use for crucibles. The chief economical use made of it has been in facing the sand moulds for iron castings, for which purpose it is ground to a fine powder. Some of the finer parts are also used to manufacture pencils. Many hundred tons of graphite from this deposit have already been taken out since the mine was opened two years ago, and the supply may be esteemed inexhaustible. The vein or bed reäppears on the opposite side of the St. John's river, and on the side now opened it has been traced over a mile. The position of the deposit in conformable metamorphic schists, suggests the conjecture that this deposit of graphite may represent a former coal bed.

3. *Flora of the Tertiary Formation*, (from the Augsburg Gazette of 27th May, 1852; communicated for this Journal by W. G. Lettsom.)—The flora of the tertiary formation has been hitherto, comparatively

speaking, far less known than that of the coal formation which is of a far older date; and even in Silesia, notwithstanding its numerous and important deposits of brown coal, the entire amount of leaves, blossoms and fruits belonging to this formation, exclusive of stems of trees, did not exceed forty-three species up to the close of last year.

Since then, however, a discovery has been made which in a few months has already brought more treasures to light, than Monte Bolca in Italy and the celebrated deposit of Oeningen in Germany have done in a century. This new deposit was discovered by the Superior Councillor of Mines, Von Oeynhausen, near the end of January, of this year, in the immediate neighborhood of Breslau, at Schossnitz, near Kanth, on the railroad; it is a bed of fossil plants in tertiary clay and is unique in richness, variety, and admirable preservation. From the end of January up to the beginning of March there were already discovered no less than 130 species in about six cwt. of clay; and every fresh quantity examined gives additional results. Dr. Göppert has read a very interesting paper upon the results of the examination thus far made before the natural history section of the Breslau Society. The clay is of a whitish color; the plants seldom preserve their original texture, but usually occur as impressions of a pale brown color, in which however they are displayed with such precision that even the delicate anthers of the catkins of the willow tribe are readily distinguishable. These anthers, as well as those of the male catkins of the plane tribe, occasionally exhibit the pollen. With respect to the families and genera, it may be said that they agree, speaking in a general way, with those of the other local floras of the brown coal formation. The species are, however, for the most part different; only one species has been hitherto observed, Libocedrites salicornioides, that is met with in Silesia, in amber, and in the brown coal formation of other parts of Germany. Of the 130 species that have been found at Schossnitz up to the beginning of March, there are no less than 118 which are new. As a peculiarity in this tertiary flora may be cited the considerable number of oaks, of which already 25 varieties have been observed, whereas at present only 13 are known to occur in Europe, and for the most part the species discovered belong to those with incised leaves. There are, moreover, no less than 17 varieties of elm, some unquestionable planes, and varieties of maple perfectly distinct from any hitherto observed. The genera Daphnogene, Ceonanthus, Dombayopsis and Taxodium have been also met with. It need hardly be observed that our acquaintance with the riches of this recently discovered deposit is as yet necessarily very imperfect. Palms, which are met with in other tertiary deposits in the immediate neighborhood, have not thus far been found; indeed, no monocotyledons have been observed with the exception of a few leaves of grass. The origin of the deposit has been explained on the supposition that there existed here formerly an inland lake, into which the leaves and blossoms of the trees that perished on its banks were carried by the wind, and became subsequently imbedded in the clayey mud. This recently discovered deposit bears out the idea that although the majority of the genera of the plants occurring in the tertiary formation are similar to those now met with in Europe, although the species are different and agree rather with African forms

than ours, yet that this formation, speaking generally, contains a flora distinct from that of the actual flora of the districts mentioned, and analogous rather to that of countries situated several degrees more to the south, the flora of the deposit at Schossnitz answering, it will be seen, to that of the vegetation in the southern portion of the United States, or to that of the north of Mexico. Professor Göppert purposes to lay the results of the examination of the Schossnitz deposit before the scientific public, as far as it has at present been made, in a separate work.

4. *On the Causes which may have produced changes in the Earth's Superficial Temperature;* by W. Hopkins, Esq., (Quart. Jour. Geol. Soc., viii, 56.)—The following are some of the important deductions brought out in this extended paper, the whole of which is worthy of attentive perusal and study.

The present effect of the internal heat of the globe on the mean temperature of the surface, as deduced by Poisson, is about $\frac{1}{20}$th of a degree: and the rate of increase of temperature on descending below the surface is 1° F. for every 60 feet. If the effect of the internal heat were 1°, or twenty times the present amount, the descending rate of increase would be twenty times as great as now, or about 20° F. for every 60 feet; if 10°, the temperature at 60 feet would exceed 200° F., a physical condition inconsistent with the existence of animal life on the surface. Prof. Hopkins hence concludes that internal heat cannot have modified the external temperature within the more recent geological epochs.

The sun (and therefore our system) moves, according to O. Struve, at such a rate as to describe an arc of $\frac{1}{3}$d of a second in a year to an eye situated at the mean distance of the stars of the first magnitude; which motion would require a period of nearly 700,000 years to pass over a space equal to that of the mean distance of the stars referred to from the earth. Now, the heat of space depends on the heat of the stars or suns radiating heat into it, and this motion is changing the part of space in which the earth is. But the influence on space of stars so distant must be exceedingly small and wholly inappreciable. There is no source of *cold* among them, and the remoter distance from the stars that might be acquired would fail to modify at all the effects of our sun, and can account for none of the cold of the so-called glacial period.

Changes in the arrangement of the land and in the direction of the oceanic currents, are now generally admitted, since the able discussion of the subject by Sir Charles Lyell, to be efficient causes of variations in the earth's temperature. Prof. Hopkins discusses the effects on the isothermal lines, and on the production of glaciers, under different changes of this kind. He shows that to produce glaciers in England by an elevation of the northern part of Europe, or by an elevation of the bed of the Atlantic so as to unite the two continents, an elevation of many thousand feet would be required. The limit of perpetual snow in high latitudes is usually much above the isothermal of 32°, and somewhat below it in the tropical. In the tropics, the temperature is nearly uniform through the year, and so the limit of the snow. In colder regions this limit is the *limit in summer*, which is much above the line of the mean for 32°. The descent of glaciers is from 1,500 to 5,300 below the snow line. It hence follows that to produce glaciers on

Snowdon, in England, by raising the land, the elevation of the region must be 7,000 or 8,000 feet above the present level, or to a height of 11,000 feet, as this would be required to carry it 1,000 feet above the snow level, and the glaciers might in such a case be expected to descend 2,000 feet below the snow line.

Considering such an elevation, (or the uniting of the continents, which would require much the same conditions as to the height of the region,) very improbable and without any proof, Prof. Hopkins next considers the effect of a *subsidence* of northern Europe, and concludes that by this means, together with a diversion of the Gulf Stream, the requisite glaciers for the production of glacial effects in England would be had. A depression of 500 feet, according to his calculations, would produce a cold temperature at Snowdon, having the probable mean of 39° or 40° F., making the line of 32° F. at a height of 2,200 feet, or 800 feet below the summit of the Snowdon peak; and glaciers would then descend from the snow line to the level of the sea. If then a cold current strike on the land, this would diminish the temperature further; and should it make a difference of but 3° or 4°, it would bring the snow limit down 1,000 or 1,200 feet lower, which would account for glaciers reaching the sea, even on the lower mountains of Ireland. The same conditions would make the snow-line on the Alps 5,000 or 6,000 feet above the sea. The present climate of Fuegia illustrates well the theory.

III. Astronomy.

New Planet, (Astr. Jour., No. 45.)—Another planet was discovered on the night of June 24, 1852, by Mr. J. R. Hind, of London. It appeared like a star of the ninth magnitude, with a steady yellowish light. Its apparent place June 24, $13^{h}\cdot 13^{m}\cdot 53^{s}\cdot$ Gr. m. t. was R. A. $18^{h}\cdot 12^{m}\cdot 58^{s}\cdot 78$, N. P. D. 98° 16′ 0″·9.

IV. Miscellaneous Intelligence.

1. *Remarks on the Climate of San Francisco.—The Sea-Breeze;* by Dr. H. Gibbons, (from the California Christian Advocate of April 1, 1852.)—The tables contained in my last number,* exhibit the great excess of sea winds over land winds in every month of the year 1851, excepting January, when the excess was in favor of land winds. In this respect, the month of January in the present year, corresponds with the last. December, 1850, shows a very slight preponderance of land winds. From these data I infer the general rule, that the westerly or sea winds predominate in every month, except January and December, and that the latter month varies in this respect, being sometimes on one side and sometimes on the other.

I have already stated that the westerly winds increase both in frequency and in force from February to July, and then begin to fall off very gradually. The precise relation of sea to land winds, in each month, as to frequency, is shown by computing their per-centage of the whole number of observations. The result for the year 1851, is as follows:

* This volume, page 132.

January,	sea winds,	44	per cent.	July,	sea winds,	97	per cent.
February,	"	63	"	August,	"	97	"
March,	"	81	"	September,	"	96	"
April,	"	87	"	October,	"	78	"
May,	"	95	"	November,	"	73	"
June,	"	96	"	December,	"	38	"

To which may be added—

December, 1850,	sea winds, ...	49	per cent.
January, 1852,	"	34	"
February, 1852,	"	69	"

Whatever may be the direction of the wind in the forenoon, in the spring, summer, and autumn months, it almost invariably works round towards the west in the afternoon. So constant is this phenomenon, that in the seven months from April to October inclusive, there were but three days on which it missed: namely, on the 8th of April, the 18th of May, and the 27th of August. And these three days were all rainy, with the wind from south or south-southwest.

The sea winds are moderate in the spring until the month of May, when they begin to give trouble. In June they increase in force, reaching their greatest violence about the beginning of July. In August they begin to decline in force, though not in constancy. In September they continue steady, though moderate, and in October they lose their annoying qualities, and become gentle and agreeable.

The sea winds of summer are commonly supposed to come from the northwest. But this is a great error, arising no doubt from the fact that our citizens have mostly been accustomed to cold winds in the Atlantic States from that quarter. In the early spring they sometimes proceed from north of west. As the season advances they depart entirely from this course, and are almost invariably from south of west. From May to September, a period of five months, the direction of the afternoon sea breeze was north of west on twelve days only; and even on these occasions it was mostly within one point of west. The prevailing direction was west-southwest.

I have reason to believe that the wind off the coast, at sea, during the period referred to, is more northwardly than on land, and that it is deflected from that course about the Bay of San Francisco. Such at least is the account given by the captains of vessels navigating the coast.

There was a decided sea-breeze on 23 days in March, 17 days in April, 22 days in May, 24 days in June, every day in July and August, 28 days in September, 30 days in October, and 8 in November.

The number of afternoons that might be described as *windy*, was, in February 8, March 16, April 15, May 18, June 24, July 29, August 23, September 19, October 8, November 2. On the 162 days thus noted, the mornings were seldom windy, the wind rising above a moderate breeze in the forenoon on 34 days only. In May there were 5 days windy at sunrise, and one in June; but not one in the months of April, July, August, September and October.

The sea-breeze generally rises to its height soon after noon-day, mostly between one and two o'clock, but sometimes not till three or four. It commonly falls about sunset, or soon after. Sometimes it

continues till midnight. In the early part of the season it is apt to set in earlier and continue later. There were 8 windy evenings in May, 11 in June, 11 in July, 5 in August and none in September.

The idea of mist and vapor is commonly associated with these winds; but the sky is clear, or partially so, more than half the time. There were 6 cloudy mornings in May, 11 in June, 16 in July, 21 in August, and 22 in September. About 9 or 10 o'clock, the clouds mostly broke away rapidly, a light breeze springing up at the same time. Several hours of very pleasant weather occurred towards noon, almost every day. The sun shone forth with genial warmth, the mercury rising generally from about 50 at sunrise, to 60 or 65 at noon. But when the sun had reached the zenith, the wind rapidly increased, coming down in gusts from the hills, which separate the city from the ocean, and often bringing with it clouds of mist. But the dampness is never sufficient to prevent the elevation of clouds of dust and sand, which sport through the streets in the most lively manner. The mercury falls suddenly, and long before sunset it fixes itself within a few degrees above 50, where it sticks pertinaciously till next morning; often not moving a hair's breadth for twelve hours. Sometimes I have examined the instrument on the idea that some defect had fixed the column immovable. The chilling temperature adds to the effect of cloud and dust. Persons who have business out of doors are seen buttoning up their coats or overcoats, and rubbing industriously at the various apertures about the face as they hurry through the streets, in the worst possible humor. Such weather, at the summer solstice, with an almost vertical sun, is pronounced "perfectly ridiculous!"

The mist often increases towards evening, and when the wind falls, remains all night in the shape of a heavy fog. Sometimes, when the sun has been shining brightly, the mist comes in from the ocean in one great wave, and suddenly submerges the landscape. In a few minutes it may vanish, and give place to the cheerful sunshine. In short there is no conceivable admixture of wind, dust, cloud, fog and sunshine, that is not constantly on hand during the summer at San Francisco. Not unfrequently you are tantalized with a rainbow at sunset. Once I saw a solar rainbow before night in the east, and soon afterwards another bow in the west, made by the moon.

I have already noticed the almost constant prevalence of the west and southwest currents. As the sea-breeze becomes established, the entire absence of winds from north and northwest is remarkable. In the month of May, and in the beginning of June there were a few light breezes from that quarter. But from the 13th of June until near the middle of October, a period of four months, there is not a solitary observation noted in my record, even of the lightest or most transient wind, from north or northwest; I think it probable that the same cannot be said of any other spot on the globe, in the north temperate zone.

The uniformity of the summer weather is occasionally broken by the intervention of a few warm and pleasant days, when the wind is not high enough to convert summer into winter. Under these circumstances the thermometer mounts to 70 or 75. In the later spring and early autumn months it is warmer. But as soon as the "summer" has fairly set in, flannels and firewood are in almost constant demand, at least until August.

No one but an actual observer can appreciate the utter impotency of an almost vertical sun, during a brisk sea-breeze. The rays of the sun have scarcely more warmth than moon beams. Instead of raising the thermometer 30 or 40 degrees, they seldom produce more than ten degrees of elevation, in the sweep of the wind.

Such is the "summer" at San Francisco. Every body complains of the chilly winds, the mist and the dust. If you have nothing to do but sit in the house you are perfectly comfortable. Even for out-door employment or exercise, the mornings are almost invariably pleasant. The evenings are generally too cool to sit without fire, and the nights are never too warm to dispense with blankets. For the purpose of rest and sleep, the night in California is perfectly luxurious all the year through.

It might be inferred that a climate such as I have described, is unfavorable to health, especially with persons liable to diseases of the chest. But the fact is just the reverse. The tone and vigor given to the animal frame by the uninterruptedly bracing temperature, appear to raise it above the control of inherent tendencies to pulmonic disorders. I believe the humid and saline condition of the atmosphere coöperates in the benefit. But I shall consider this subject more fully under a distinct head.

In all other parts of California, except the region about the Bay of San Francisco, the summer is very different. Along the coast are mists and sea breezes, but the winds are moderate, and not so chilling. Inland, they do not extend beyond the barrier of hills which skirt the coast. A distance of fifty miles in any direction from San Francisco, brings you into a different climate. In a southeast course towards San José, you escape the winds and fogs of summer by traveling 20 or 30 miles. Even in Contra Costa directly accross the Bay, they are less severe, though the trees show, by their semi-prostrate attitudes, the direction of the prevailing atmospheric currents.

The general principles on which depend the diurnal currents of air, which set in from sea to land, are well known. The land being more heated than the ocean by the sun's rays, the superincumbent heated air rises in a steady column. Its place must be supplied from some quarter, and the colder and denser air of the ocean accordingly flows in, constituting a sea-breeze. Independently of this, we have the universal westerly current, coinciding in its course and tending to add strength and constancy to the sea-breeze, while the topographical features of the Bay of San Francisco, and the region of country bordering on it enhance the effect. These several causes combined, will explain the extraordinary constancy and force of the westerly winds at this point.

The importance of these winds in connection with the climate of San Francisco, has led me to dilate much more than I intended on taking up the subject. There are other incidents of the climate yet to be considered.

2. *Heat of the Solar Disk.*—M. Secchi, of Rome, has made a series of photometric experiments on the disk of the sun, by means of a thermo-electric pile. He has found that the heat of the borders of the disk is nearly half that of the centre, which confirms, as regards radiation of heat, what was already known for light and chemical action. But

he observed further, that the heat was not the same at all points equidistant from the centre; and that the place of maximum temperature was 3′ above the centre; the isothermal curves were a species of parabola. The sun's surface hence differs in temperature not only because of the absorption due to its atmosphere, but also from certain inherent differences in the surface itself. But M. Secchi also remarks that at the time of the observations, the 20th, 21st and 23d of March, the solar equator was raised about 2′·6 above the centre, and hence the inferior part of the disk presented the south pole of the sun, while the north pole was concealed; and, moreover, the ascertained point of its greatest heat *lies in the solar equator*. The conclusion therefore follows that the *equatorial regions of the sun are hotter than the polar*. M. Secchi's observations did not extend to the spots of the sun; yet in a few trials they were found to produce a sensible diminution of temperature. He says that the prevalence of the spots about the equatorial region corresponds well with the view that this part is the hottest in the sun.—*L'Institut, No.* 957.

3. *On Rain Waters.*—M. Chatin makes the following statements as results of his observations:—

(1.) The chlorids, which abound in the rains of maritime countries, are at Paris more abundant than in the waters of the Seine whenever the wind blows from the sea.

(2.) Sulphates exist in a notable quantity in the rain of Paris and in that of Central France; rain waters, though generally containing less of chlorids than the waters of rivers, usually surpass the latter in the proportion of sulphates.

(3.) Salts of lime and soda are contained in rain waters in an appreciable quantity.

(4.) Rain waters are especially distinguished by containing even half a decigramme to a litre of azotised organic matter, which may be represented in its composition by a mixture of ulmate of ammonia and ulmic acid; this ingredient is found also in the lower strata of the atmosphere (though less at Turin and on the borders of the sea than at Paris and in Maurienne), whence it is deposited by the dews and mists, and may be separated by washing.

(5.) Argillaceous earths retain better than lighter soils this principle dissolved in rain waters. The atmosphere, and the rains which wash it, perform an important part in agriculture, in restoring to the soil a portion of soluble mineral and organic matters highly useful to vegetation.

4. *Pendulum Experiment.*—In this Journal, vol. xii, p. 399, a paper upon the Pendulum in the Philosophical Transactions for 1742, is attributed to Marquis de Poli, a statement taken from the London, Edinburgh and Dublin Phil. Mag. for 1851.—M. Secchi, of Rome, observes (L'Institut, No. 951, March, 1852), that the author, as stated in the Transactions referred to (years 1742–43, No. 468), was *Marquis de Poleni*. The title is in Latin, as follows: *Johannis Marchionis Poleni*, R.S.S. de novis quibusdam cogitationibus ad explorandum num pendula vi aliqua centrifuga perturbentur, commentariolum illustrissimæ Societati regali Londinensi oblatum. The author was an Italian, born at Venice in 1683. The paragraph referred to, as containing the

knowledge of the phenomena relating to the pendulum, is the following: —Tum animadvertam (considerata hypothesi Terræ motæ) in una penduli oscillatione non describi ab ejus centro perfecte unum eundemque arcum in plano eodem: nihilo tamen secius cum nascentes inde differentiæ rem meam non turbent, negligi a me tuto possunt; sufficitque hæc semel indicavisse, etc.

In M. Secchi's experiments with the pendulum he obtained the mean hourly deviation 9° 53′ 16″. The calculated deviation for the latitude of Rome is, for an hour of sidereal time, 10° 1′ 2″·7.

5. *Microscopic Photographs*, (Athenæum, May 22, 1852.)—As the photographic delineation of microscopic objects appears to be occupying the attention of many at the present moment, I beg to inclose one or two examples in that way, in the hope of obtaining some further information on the subject through the medium of your journal, should you consider them sufficiently noteworthy. The collodion process on glass offers peculiar facilities for working with the microscope; but as the accumulation of the plates is highly inconvenient, it appeared desirable that some method should be devised for the preservation of the picture without the glass. This may be effected by transferring it to a piece of waxed paper, which forms a most excellent substitute. The process is very easy. The picture having been obtained, the film of collodion is floated off the glass under water, and removed to a bath of isinglass so weak as to be fluid when cold; in this bath the waxed paper having been previously soaked for a few minutes, the arrangement and extension of the pellicle is effected by gently moving it with the fingers, and then carefully raising up both it and the paper together, holding them so as to let the water run from between them. It is necessary to hold both, for the film slips about very easily. Blotting paper will then absorb some of the superfluous water, and the remainder may be forced out by rubbing slightly, but always in one direction. By drying the whole under pressure the picture will be found firmly adherent to the paper. I am far from offering the specimens sent as perfect examples of what may be effected by the aid of the microscope,—but shall be glad to know whether the transfer of the film of collodion from the glass plate to the waxed paper may be considered an improvement, as it would certainly seem to offer some advantages. I may observe with respect to the production of images of transparent objects, that there may be some doubt whether in all cases the photographic picture is true:—for the light being decomposed in its passage through them, will, of course, affect the faithfulness of the image. I am, &c.,

Royal Institution, Edinburgh. E. W. Dallas.

Mr. Archer has been in the habit of separating the film of collodion from the glass and transferring it to paper; but it appears to us that there are some valuable suggestions in our correspondent's note.

6. *On a Lunar Rainbow;* by C. M. Tracy, (from a letter dated Lynn, Mass., Aug. 1, 1852.)—Friday, July 30, at 8h. 10m. P. M., a fine lunar rainbow was observed here, formed by the newly risen moon at the close of a slight shower. The arch was without interruption and beautifully distinct; being placed against a heavy cloud which occupied the western sky. Slight prismatic tints were discoverable at one time

on the northern limb, otherwise the color was only the delicate white which seems characteristic of this phenomenon. The span of the arch, measuring on the horizon, was about 105°, and its approximate height, 42°. Whole duration about ten minutes. To give a clearer idea of the position of things, I may remark that the time of sunset was 7h. 21m., and that of moonrise six minutes later.

7. *Meteorological Observations taken by the Royal Astronomer at the Observatory of Athens*, (Greece), *on the Hill of the Nymphs, west of the Acropolis, and at an elevation of* 120 *French metres above the surface of the sea*, (translated from the official Greek report, by Rev. JOHN H. HILL, of Athens.)—Mean temperature during the month of

January,	1851,	+6°·	Reaumur.	July,	1851,	+21°·1	Reaumur.
February,	"	7°·6	"	August,	"	20°·8	"
March,	"	8°·8	"	September,	"	18°·4	"
April,	"	12°·9	"	October,	"	14°·3	"
May,	"	17°·6	"	November,	"	9°·5	"
June,	"	19°·9	"	December,	"	7°·1	"

Mean temperature throughout the year, +13°·7 Reaumur. During winter Reaumur's thermometer rarely falls below −3°, and during the period of the greatest heat of summer it rises to +29°· in the shade, and to +45°· in the sun.

The mean state of the barometer (at a temperature of 0°· of the mercury) is 753·02 (thousandth parts of a metre). The highest and lowest extremes observed are respectively 765·00 and 744·02.

Mean degree of humidity, 66·67 per cent.

The prevailing winds are southerly, northeasterly and north; the latter during the months of June, July and August are strong, and hot, and known as the Etesian winds. The rains generally fall in heavy showers (torrents), but are of short duration. Rain seldom falls in summer, or snow in winter. Thunder and lightning, loud, vivid, but unfrequent. The sky is generally without clouds, and in winter very bright.

8. *Aurora Borealis.*—The aurora was observed in Belgium by Prof. Montigny, of Namur, on the evening of the 28th of December last. It was first seen at 7½h., and by 9½h. it had almost wholly disappeared. A low dark zone in the north was surmounted by a zone of light, from which occasionally rays or columns shot up, especially in the northwest. Towards 7¾h. the light of the zone lessened, the diminution of light seeming to propagate itself rapidly from northwest to northeast through the whole length of the zone.—*L'Institut, No.* 965, p. 208.

9. *Freedom of the Arabs from Leprosy.*—M. GUYON, in a note to the Academy of Sciences, Paris, attributes the absence of leprosy among the Arabs to their living under the direct action of light and air in tents, while the Kabyles, who often suffer from this disease, live in fixed dwellings often more or less beneath the level of the earth's surface.—*L'Institut, No.* 965.

10. *Prizes of the Academy of Sciences of Paris.*—At the session of the 22d of March, the prize in Astronomy for 1852 was divided between Mr. Hind and M. de Gasparis, the former for his discovery of the new planet Irene, and the latter for that of Eunomia. The Cuvierian prize

(a triennial prize and never before awarded) was given to Prof. Agassiz for his Researches on Fossil Fishes.

Among the prizes offered, is one for 1854 in the department of Mathematics, as follows:—To determine the equations of the general movements of the earth's atmosphere, having in view the rotation of the earth, the calorific action of the sun, and the attraction of the sun and moon. The authors are desired to exhibit the concordance of their theory with the best observations on the atmospheric movements. Even if the whole question is not resolved, but some important steps are made towards its solution, the prize will be awarded by the Academy. The prize is a gold medal of 3,000 francs.

There is also an extraordinary prize for 1853, on the application of steam to navigation. The prize was proposed first in 1836, and has been continued to 1838, 1841, 1844, 1848, and finally to 1853. It is offered "for the best work or memoir on the most advantageous employment of steam for steamships, and upon the best system of mechanism, 'installation,' stowage, and armament for such vessels." The prize is 6,000 francs. Time, Dec. 1, 1853.

11. M. Oberhauser, the distinguished microscopic artist, has been decorated with the Cross of Merit, by the king of Bavaria.

12. Dr. Mantell, of London, has received from the British government a pension of one hundred pounds sterling in testimony of his distinguished services to science.

13. Mitscherlich, of Berlin, was lately elected foreign associate of the Academy of Sciences, in place of Oersted, of Copenhagen, deceased.

OBITUARY.

14. The Academy of Sciences, in Stockholm, has lost the oldest of its members in the person of M. Wilhelm Hisinger, the mineralogist, who has died at the age of 86. Norway has also been deprived of one of her most learned historians, Dr. Nilo Wulfsberg, aged 67.

15. Dr. James B. Rogers, Professor of Chemistry in the Medical Department of the University of Pennsylvania, died in Philadelphia, in June last.

V. Bibliography.

1. *On the Osteology of the head of Hippopotamus and a description of the Osteological Characters of a new genus of Hippopotamidæ;* by Dr. J. Leidy. 15 pp. 4to, with a plate. (From the Journal of the Acad. Nat. Sci., vol. ii, 2d ser., Part 3, 1852.)—Dr. Leidy in this paper describes specimens of the skulls of the Hippopotamus amphibius, *Linn.* (H. senegalensis, *Desmoulins*) and H. capensis, *Desmoulins*, in the collections of the Academy. He next takes up, with much detail, the H. minor of Morton, which he had referred to a new genus *Chærodes*, in the Proceedings of the Academy (vi, 52), but now names *Chæropsis Liberiensis*, the name Chærodes being in use for a genus of Insects. The specimens of this species in the collections of the Academy now include an entire skeleton, besides an imperfect skin, both from a nearly adult animal, from St. Paul's River, Africa; and also two other separate skulls. The length of the skeleton is 5 feet 8 inches.

2. *Exploration and Survey of the Valley of the Great Salt Lake of Utah;* by HOWARD STANSBURY, Capt. Corps Topog. Engineers, U.S.A. 486 pp. 8vo, with numerous plates. 1852. Senate Exec. Doc. No. 3, 1851.—This volume includes a description and survey of the Geography, Natural History and Minerals of the Utah region, an Analysis of its Waters, with an authentic account of the Mormon Settlement; also, a Reconnoissance of a New Route through the Rocky Mountains, with two maps. Appendix A. contains a Table of distances along the Route travelled by the Expedition in 1849.—Appendix B. Latitudes and Longitudes in the Great Salt Lake Valley.—Appendix C. Zoology, including the descriptions of the Quadrupeds and Birds, by Prof. Spencer F. Baird; the Reptiles, by Prof. Baird and Chas. Girard; the Insects, by Prof. Haldeman.—Appendix D. Botany, by Prof. John Torrey.—Appendix E. Geology and Palæontology, by James Hall.—Appendix F. Chemical Analyses, &c., by Dr. L. D. Gale.—Appendix G. Meteorological Tables. The natural history portion, as well as the rest of the work, is illustrated by excellent plates, and the whole volume is of high value to science.

3. *DeCandolle's Prodromus Syst. Nat. Regni Vegetabilis.* Pars XIII, Sect. Prior. Paris, 10 Mai, 1852, pp. 741.—This long-expected volume, which finishes the *Monopetalæ*, has at length reached us. It is entirely occupied with the SOLANACEÆ, by Prof. Duval, and the PLANTAGINACEÆ, by Decaisne. The former family is made to include two tribes, which perhaps should rather be called suborders, the *Nolaneæ*, and the *Solaneæ*, of which the first is divided into two subtribes, the second, into nine. There are 63 admitted genera. Of the species described, about 1,700 in number, 165 belong to Cestrum, 58 to Nicotiana, 60 to Physalis, and 900 to Solanum! A proper revision will doubtless considerably reduce this number, but still it would appear to outnumber Senecio. The species of *Plantago*, 207 in number, appear to be thrown into excellent sections. Several of the North American species will probably fall into P. gnaphalioides, *Nutt.* The *Diapensieæ*, comprising two genera, each of a single species, are referred by Alphonse De Candolle to the order *Polemoniaceæ*. The 14th volume, which, we presume, will go to press without delay, is to comprise the *Polygoneæ*, *Thymelaceæ*, *Proteaceæ*, &c., principally elaborated by Prof. Meisner, of Basle. We are glad to hear that Prof. Alphonse DeCandolle will himself prepare the *Euphorbiaceæ* and the *Urticaceæ*. A. GR.

4. *A detailed description of the British Palæozoic Fossils in the Geological Museum of the University of Cambridge;* by FRED. MCCOY, Professor of Geol. and Min., Queen's College, Belfast. 1st Fasciculus RADIATA AND ARTICULATA. 4to. Reeve & Benham, Cambridge; J. W. Parker & Son, London.—We would again call attention to this important volume on Palæontology,* published mostly at the expense of Prof. Sedgwick, it being Part II. of his British Palæozoic Rocks. Prof. McCoy's excellent work treats of the fossils of the same rocks that abound through the middle and western states of this country, and should be in the hands of all interested in this department of science.

* See our former notice, vol. xii, p. 448.

5. *Annales de L'Observatoire Physique Central de Russie*, published by order of his majesty the Emperor Nicolas I, by A. T. KUPFFER. No. 1, for 1848, 606 pp. 4to; No. 2, for 1848, 182 and 260 pp., with plates; No. 3, for 1848, 104 pp., with plates. St. Petersburg, 1851.

At Fellin, lat. 58° 22′ N., long. 43° 18′ E. from Ferro, the mean temperature of the months for 1848 was as follows in Reaumur's scale:—

Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
−5°·48	−4·73	−1·44	+4·20	+8·69	+11·81	+12·69	+10·68	+6·57	+2·09	−1·85	−4·78

The mean temperature of the year was +3°·20. The winds were from the north 35 days, northeast 7, east 50, southeast 40, south 46, southwest 101, west 72, northwest 14. The southwest wind blew for 11 days in October, 10 in each January, July and August, 8 to 9 in June, September, November, December, 7 in February, March, April; 5 in May. The northwest, blew 1 day in each month except May and June, which blew 2 days; the southeast, 2 to 4 days each month through the warmer half year, and 3 to 5 each through the colder half year.

6. *Compte-Rendu Annuel addressé à M. Le Comte Wrontchenko, Ministre des Finances, par le Directeur de l'Observatoire Physique Central*, A. T. KUPFFER. Année, 1850. 24 pp. 4to. St. Petersburg, 1851.

7. *Journal de Conchyliologie comprenant l'etude des Animaux, des Coquilles Vivantes et des Coquilles Fossiles.* Publié sous la Direction de M. PETIT DE LA SAUSSAYE. Paris.—This important Journal is a quarterly, and was begun in 1850. The volume for that year contains 450 pages with 15 plates, colored or uncolored, and includes descriptions of new species, anatomical details, &c., by men of eminence in the science. Price 18*fr.* Address M. Petit de la Saussaye, Rue Neuve-des-Mathurins 19.

8. *Considerazioni sulla Geologia della Toscana dei Professori Cav. Paolo Savi e G. Meneghini.* 246 pp. 8vo., with 1 plate of sections. Firenze (Florence), 1851. The distinguished authors of the Geology of Tuscany, Professors SAVI and MENEGHINI, aim in their work to present together the geological notices of the structure of Tuscany hitherto published, especially the results of Murchison in his classical work, and also to fill out what is unfinished in the investigations of this geologist. The rocks described are, beginning with the uppermost, as follows:—

1. Macigno (sandstone) and Calcareous Alberese.
2. Nummulitic limestone and upper Galestrini schist.
3. Argillaceous schist, called lower Galestrini schist and compact limestone.
4. Dark gray limestone, with flint or hornstone.
5. Variegated schist and impure limestone.
6. Ammonitiferous limestone.
7. Saliferous limestone.
8. Dark gray limestone without hornstone.
9. Quartzose Anagenite and schist of Verrucano.

These rocks are described in order, and their geological age discussed. The following are the epochs assigned to them:—

1. Eocene Tertiary; 2. Lower Eocene; 3. Upper Cretaceous; 4. Cretaceous; 5 and 6. Jurassic; 7. Liassic or Triassic; 8 and 9, in part at least Carboniferous.

The descriptions of the fossils, among which are many new species, occupy about 140 pages of the work.

9. *Uber die Larven und die Metamorphose der Echinodermen;* by JOH. MULLER, Vierte Abhandlung. 50 pp. 4to, with 9 copper-plates. Berlin, 1852. From the Transactions of the Königl. Akad. der Wissenschaften zu Berlin.

10. *Nineteenth Annual Report of the Royal Cornwall Polytechnic Society.* 8vo. Falmouth, 1851.—This report for 1851 contains a paper on the Actiniæ of Falmouth and its neighborhood, by W. P. COCKS, Esq., embracing descriptions of numerous species, as well as two crowded plates of figures. There is also a list of the species collected about Falmouth in other branches of Zoology, by the same author, in addition to information on patents and meteorological registers.

11. *Fifth Annual Report of the Regents of the University of New York* on the Condition of the State Cabinet of Natural History and the Historical and Antiquarian Collection annexed thereto. 118 pp. 8vo, with numerous wood-cuts and 32 lithographic plates.—The wood-cuts and plates are principally in illustration of Indian relics or manufactures, and the latter are mostly colored. There are also two zoological plates, one of the *Cervus alces*, or moose, and another of the *Mustela canadensis*. The moose was taken in Herkimer Co., N. Y.; it measured 10 feet 2 inches from point of nose to root of tail; height of shoulder, 6 feet 3 inches; length of tail, 8 inches.

12. *Sixty-fifth Annual Report of the Regents of the University of the State of New York.* 400 pp. 8vo. 1852.—This report, besides its review of the schools and colleges of the State, contains an appendix of 150 pages, embracing numerous meteorological tables and registers of atmospheric phenomena, among which are tables of meteorological observations made at Norway House on Nelson's River, at Mishipicoten, at Lake Superior, at Tabreez and Tehran in Persia, at Constantinople, Broosa, Erzeroom, Trebizond, communicated by Jas. H. Coffin; also, contributions by Prof. C. Dewey, F. B. Hough, J. L. Hendrick and others, relating in part to Auroras, Halos, Parhelia, etc.

13. *Transactions of the American Philosophical Society of Philadelphia*, vol. x, new series, Part II.

SEARS C. WALKER: Investigations which led to the detection of the coincidence between the computed place of the planet Leverrier and the observed place of a star recorded by Lalande in May, 1795.—p. 341.

C. D. MEIGS: On the Reproduction of the Opossum (Didelphys virginiana).—p. 153.

Capt. R. F. STOCKTON, U. S. N.: On some of the results of a series of experiments relative to different parts of Gunnery.—p. 167.

R. A. TILGHMAN: On the decomposing power of water at high temperatures.—p. 173.

C. M. WETHERILL: On the neutral Sulphate of Oxyd of Ethyle, and the products of its decomposition by water.—p. 177.

C. A. JAHN: De calculo Eclipsium Besseliano.—p. 183.

Lieut. J. M. GILLISS: On the Longitude of Washington computed from the moon-culminations observed during the years 1839–1842, inclusive.—p. 211.

MIERS FISHER LONGSTRETH: On the Accuracy of the Tabular Longitude of the Moon to be obtained by the construction of new Lunar Tables.—p. 225.

J. LEIDY: On the organization of the genus Gregarina of Dufour.—p. 233.

J. LEIDY: Some observations on Nematoidea Imperfecta and description of three Parasitic Infusoria.—p. 241, with plates, (pl. 10, 11.)

Dr. BETTELHEIM: Meteorological Observations at Loo-Choo.—p. 245.

I. LEA: Descriptions of new species of Unionidæ.—p. 253, with plates 12 to 29.

I. LEA: Descriptions of a new genus (Basistoma) of the family Melaniana, together with some new species of American Melaniæ.—p. 295, with plate 30.

I. LEA: Description of a new species of Helix from California, and a new characteristic form of certain American Colimaceæ.—p. 302, and plate 30.

I. LEA: On the Fossil Footmarks in the Red Sandstone of Pottsville, Schuylkill county, Pa.—p. 307, and plates 31, 32, 33.

14. *Annals of the Lyceum of Natural History of New York*, vol. v, No. 6, February, 1852, and Nos. 7 and 8, June, 1852.

JOHN L. LE CONTE: New species of Californian Coleoptera.—pp. 185–206.

S. F. BAIRD: Description of a new species of Sylvicola (S. Kirtlandii), with a plate (pl. 6).—p. 217.

TEMPLE PRIME: Descriptions of two new species of Fresh-water shells (Cyclas securis and Pisidium compressum), with figures on plate 6.—p. 218.

J. G. BELL: Description of a new species of the genus Fuligula (F. viola).—p. 219.

G. N. LAWRENCE: Ornithological notes.—p. 220.

J. H. REDFIELD: Descriptions of new species of Marginella (M. vexillum, amabilis, antiqua), with notes on sundry species of Marginella and Cypræa.—p. 224.

C. B. ADAMS: Catalogue of shells collected at Panama, with notes on Synonymy, Station, and Habitat.—p. 229–296, and to be continued.

PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, fifth Meeting, held at Cincinnati, Ohio, May, 1851. 262 pp. 8vo. *Washington*, 1851. Published by the citizens of Cincinnati. Copies are in the hands of Prof. S. F. Baird, of the Smithsonian Institution.

J. R. HIND: The Solar System. 12mo, pp. 198. From the English edition. *New York*, 1852. G. P. Putnam.

A. VON HUMBOLDT: Cosmos. Vol. 4, 12mo, 234 pp., translated by E. C. Otté and H. B. Paul. *New York*, 1852. Harpers.

J. TORREY: Plantæ Fremontianæ; or Descriptions of Plants collected in California by Col. J. C. Fremont. 4to, with 12 plates. (In the press.)

DR. F. E. MELSHEIMER: Catalogue of the Coleoptera of the United States. 8vo. (In the press.)

REPORT on Light Houses. 760 pp. 8vo, with numerous plates. 1852. Ex. Doc. 28, 32d Congress, 1st session.

JUSTIN R. LOOMIS, Prof. Chem. and Geol. in Waterville Coll.: Elements of Geology, adapted to the use of Schools and Colleges. 198 pp. 12mo, with numerous illustrations. *Boston*, 1852. Gould & Lincoln.

ANNUAL REPORT of the Trustees of the State Library of New York. 288 pp. 8vo.

M. FARADAY: Experimental researches in Electricity, 28th series, On lines of magnetic force, their definite character, and their distribution within a magnet and through space; 29th series, On the employment of the induced magneto-electric cur-

rent as a test and measure of magnetic forces, and on the amount and general disposition of the forces of a magnet when associated with other magnets. Trans. Roy. Soc. 1852.

J. H. Balfour: Elements of Structural Botany. 1 vol. demy, 8vo., with 1060 illustrations, forming Part I. of a New Botanic Class Book. 1852. *London and Edinb.*

Sestertius Holt: Zoological Anecdotes. Post, 8vo. *London*, 1852. Bentley 10*s.* 6*d.*

T. Horsfield: Plantæ Javanicæ rariores, etc. Descrip. et charact. plurimarum elaboravit J. J. Bennett; observ. struct. et affin. præsertim respicientes passim adjecit Robertus Brown. 4th and concluding part. Imp. 4to, with a map of Java. *London*, 1852. 21*s.*; col. 30*s.*

J. Sedgwick: The Law of Storms. The true Principle of the Law of Storms practically arranged for both Hemispheres. 182 pp. 8vo. *London*, 1852. 3*s.* 6*d.*

W. Sturgeon: Scientific Researches, Experimental and Theoretical, in Electricity, Magnetism and Electro-Chemistry; with copper-plates. 4to, 562 pp., 18 plates. *London*, 1852. 3*s.* 6*d.*

John Arthur Phillips: A Manual of Metallurgy, or Practical Treatise on the Chemistry of the Metals. 8vo, pp. 590. 1852, *London.* Griffin.

Dr. J. D. Hooker: Flora of New Zealand. With colored plates. *London*, 1852. Reeve & Co. Part I. just issued.

Berthold Seemann: Flora of Esquimaux-land, including the Sound to Point Barrow and the adjacent Islands. 40 pp. 4to, with plates. *London*, 1852. Reeve & Co. 10*s.* Forms Part I. of the Botany of H. M. S. Herald.

F. Walker: Insecta Brittanica; Diptera. Vol. 1, 8vo, with plates. *London.* Reeve & Co. 25*s.*, plain.

Henry Sowerby: Popular Mineralogy. In royal 16mo, with 20 plates. *London.* Reeve & Co. 10*s.* 6*d.*, colored.

Thomas Moore: Popular History of British Ferns, comprising all the species. Royal 16mo, with 20 plates. *London.* Reeve & Co. 10*s.* 6*d.*, colored.

Robert Hunt: Elementary Physics. Foolscap 8vo. *London.* Reeve & Co. 10*s.* 6*d.*

Charles Knight's Imperial Cyclopedia of Sciences and Arts. Illustrated with numerous engravings on steel and wood. *London.* Part I. announced to appear in August, 1852. To be completed in 36 parts, and 9 volumes. 316 pp. each part. 15*s.* per vol.

Meyer's British Birds and their Eggs. *London.* No. III. ready. 2*s.*

Wood's British Entomology. A complete illustrated catalogue of the Lepidopterous Insects of Great Britain. New edition, revised and improved, by J. O. Westwood. This work will contain nearly 2,000 colored figures. No. III. ready. 3*s.* 6*d.*

Macgillivray's British Birds. 4th and 5th volumes, completing the work, now ready. *London.* W. S. Orr & Co. Price of 5 vols. demy 8vo, 2*l.* 10*s.*, cloth.

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PROCEEDINGS OF THE BOSTON SOCIETY OF NATURAL HISTORY.—MAY, 1852.—p. 177. Coal near Marietta and Wheeling; *Dr. Lesquereux.* The Stigmaria not roots of Sigillaria; *C. T. Jackson.*—p. 181. Note on the drift of Long Island affording shells.—p. 183. On the difference of the climates of Germany and New England.—p. 185. On two new genera and two species of Nemertes, (Hecate (G.) elegans and Poseidon (G.) Colei;) *C. Girard.*—p. 188. Notice of a mass of anthracite coal from the calciferous sandstone of New York, attributed to a fucoidal origin.—p. 189. On the equivalency in geological age of the coal formation of the United States, and the anthraciferous strata of France in the departments of Mayenne and Sarthe.—JUNE.—p. 193. New genus and species of Tubulariдæ (Globiceps tiarella); *W. O. Ayres.*—p. 199. On resinous nature of coal plants; *J. E. Teschemacher.*—p. 202. On a shark taken in the Bay of Fundy; *R. Foulis.*—p. 207. A new Holothuria (Pentamera, *A. pulcherrima*); *W. O. Ayres.*

APPENDIX.

On the Classification of the Crustacea Choristopoda or Tetradecapoda; by JAMES D. DANA.

THE term Choristopoda, applied to the Tetradecapods, alludes to the subdivision of the thorax into segments, each devoted to a separate pair of legs; this is a prominent peculiarity of the species, distinguishing them from all the Podophthalmia, and with rare exceptions from the Entomostraca.

This division of Crustacea is subdivided by Latreille and other subsequent authors into three groups, the *Amphipoda*, *Læmipoda* and *Isopoda*. Kröyer has suggested that the Læmipods are essentially Amphipods in structure, and his investigations have shown that in the only important distinction between them, that based upon the abdomen, the two groups are united by gradual transitions. In the organs of the mouth, they are the same,—also in having thoracic branchial appendages and in the position of the thoracic legs; and moreover the abdominal appendages conform to the same type, as is seen when the abdomen in the Caprellidæ is partly elongated, as in the genus Cercops of Kröyer.

Rejecting the division Læmipoda, the number of tribes is reduced to two. There is however a third tribe, which hitherto has not been recognized. It is intermediate in its characteristics between the Amphipods and Isopods.

The AMPHIPODA are uniformly characterized by having—

1. The three posterior pairs of thoracic legs thrown backward and more or less obliquely outward, and constituting one series, while the four anterior pairs are thrown forward and outward, in another series; this arrangement may be represented by the figures 4 : 3, (or 2+2 : 3, as the four pairs of the first series are often in two sets of two pairs each).
2. The branchial appendages thoracic.
3. The abdominal members in two sets, the three anterior pairs subnatatory, the three posterior styliform—an arrangement represented by the figures 3 : 3.

The true ISOPODA, on the contrary, have—

1. The four posterior pairs of thoracic legs in the backward series, and three anterior pairs in the forward series—3 : 4.
2. The branchial organs abdominal.
3. The abdominal members in two sets, the 5 anterior pairs branchial (the first sometimes operculiform), and only the last styliform—5 : 1.

These are two distinct types of structure of fundamental character; and any species which do not partake of these peculiarities are inter-

mediate forms and are naturally arranged in a separate group. These constitute the tribe here named

The Anisopoda.

1. Like *Amphipoda*, the three posterior pairs of thoracic legs are in one series, and the four anterior in a different series or usually in sets of two pairs each;—4(or 2+2) : 3.
2. Like *Isopoda*, the three posterior pairs of abdominal members are not styliform, only the last pair being of this character; the branchial organs are abdominal and not thoracic, with a rare exception.

These are constant characteristics of the whole group. Although strongly *Amphipodan*, the species have in general more external resemblance to the *Isopods;* yet the intermediate character of some genera is so obvious that they have been arranged in the former group by one author and in the latter by another.

The genera that pertain to this tribe, Anisopoda, are the following: *Arcturus* and the allied *Anthura*, *Tanais*, *Apseudes*, *Rhœa*, *Praniza*, *Anceus*, *Serolis*, *Bopyrus* and allied. Each of the larger subdivisions of the Isopoda, as laid down by Edwards, affords one or more genera, and they are genera which in his system are in some instances marked off as anomalous in character.

In *Arcturus* and *Anthura*, the *thoracic* members have the Amphipod character, the series being 4 (or 2+2) : 3, and not 3 : 4 as in the Isopods. The abdominal appendages are like those of Idotæa.

In *Tanais*, there is the same arrangement. The abdominal appendages are Isopodan in being characterized by the series 5 : 1, but the 5 anterior are elongated and subnatatory, the abdomen is more flexibly articulated, approximating to the Amphipods; the 6th pair is a pair of stylets. *Apseudes* and *Rhœa* are closely like Tanais, and actually more resemble Amphipods than Isopods. The abdomen is more elongated, and differs from the Amphipodan abdomen mainly in having but one pair of stylets with 5 pairs of subnatatories instead of three of stylets and three of natatories.

Praniza and *Anceus* have the thoracic legs Amphipodan in their arrangement. The abdomen in Praniza is considerably elongated and flexible, approaching the Amphipodan; but the arrangement of its appendages is Isopodan.

In *Serolis*, although the general aspect of the species is strikingly Isopodan, the arrangement of the thoracic legs is Amphipodan. Further than this, the abdomen is partly Amphipodan, for instead of the series 5 : 1, it has the series 3 : 3; yet while the 3 anterior pairs are natatory as in the Amphipoda, the next two, instead of being styliform, like the last, are branchial (one opercular to the other), and in this particular they are Isopodan.

In the *Bopyri*, the thoracic legs are so arranged in a single continuous series, that it is difficult to make out the series 4 : 3 or 3 : 4. Yet in some figures, the former (the Amphipodan) arrangement is indicated. The males are closely like Tanais in some instances, both in the length of the abdomen, its free articulations and its appendages.* In a female not adult of the *Bopyrus abdominalis*, figured by Kröyer,† all the tho-

* See Kröyer, in Voy. Scand., pl. 28, fig. 1 A., *Dajus Mysidis*. † Ibid. pl. 29, fig. 1*l*.

racic legs of one side are obsolete excepting the 3 posterior, a fact pointing to the Amphipod arrangement 4:3. Rathke's figure of the "*Phryxus Hippolytes*"* represents a male with the 3 posterior legs either side thrown backward and the 4 anterior forward, confirming the same view.

In *Ione*, there are *thoracic* branchial appendages, which is a wide divergence from the Isopoda. In view of these facts, we conclude that the Bopyri are properly Anisopods. The resemblance in habit to the Cymothoidæ is no objection, for we find this habit also in the Cyami, species still more remote. In fact, the male Bopyri show that the species in all essential points of structure, are nearest to Jæra and Tanais. Moreover the Jæræ are mostly parasitic.

The genera *Crossurus*, and *Liriope* of Rathke† are near Tanais, though also related in form to male Bopyri. In Liriope the thoracic legs are grouped as in Tanais, and the abdominal appendages are subnatatory or nearly Amphipodan in structure, although, like Tanais, diverse from true Amphipods in having 5 pairs subnatatory, and only one pair of stylets. Liriope is referred to the Amphipoda by Rathke. Cryptothir is the name of another related genus, a species of which was found by the author in the cavity of a living barnacle (Creusia).

We therefore adopt as the grand divisions of the Choristopoda, the three tribes, Isopoda, Anisopoda and Amphipoda.

It is an important fact, the basis of a philosophical principle, that the most sluggish and most stupid of the Decapods are found in the transition group, Anomoura. So in the Tetradecapods, the transition group, *Anisopoda*, contains those species of the order that are lowest in activity and structural perfection; for the Bopyri, the females especially, when mature, are nearly memberless, motionless and senseless.

The *Isopoda* seem to have the same relation to the *Amphipoda* that the *Brachyura* have to the *Macroura*, and are the higher in rank.

Tribe I. *Isopoda.*—The Isopoda thus stripped of genera that are not properly of the tribe, are naturally divided into three subtribes, as follows:—

Subtribus I. Idotæidea.—Appendices abdominales duæ posticæ bene operculiformes, appendices alias optime tegentes.

Subtribus II. Oniscoidea.—Appendices abdominales duæ posticæ styliformes et non operculiformes, fere terminales, raro obsoletæ.

Subtribus III. Cymothoidea.—Appendices abdominales duæ posticæ lamellatæ, apud abdominis latera dispositæ.

Tribe 2. *Anisopoda.*—Among the Anisopoda, we find the three subtribes of the Isopoda represented. Allied to the *Idotæidea*, there are *Arcturus*, *Leachia*, *Anthura*; allied to the *Oniscoidea*, the genera *Tanais*, *Apseudes*, *Bopyrus* and others related; allied to the *Cymothoidea*, the genera *Serolis*, *Praniza*, &c. Praniza is an aberrant form, abnormal in the number of its legs. The three grand divisions are hence as follows:—

Subtribus I. Serolidea, vel Anisopoda Cymothoica.—Appendices duæ posticæ abdominales lamellatæ, apud abdominis latera dispositæ.

* Fauna Norwegens, pl. 2, f. 3. † Fauna Norwegens, pp. 35 and 60, pl. 1.

Subtribus II. Arcturidæ, vel Anisopoda Idotæica.—Appendices duæ posticæ abdominales lamellatæ et bene operculiformes, appendices branchiales tegentes.

Subtribus III. Tanaidea, vel Anisopoda Oniscica.—Appendices duæ posticæ abdominales plus minusve styliformes, subterminales, interdum obsoletæ.

Tribe 3. *Amphipoda.*—The Amphipoda contain two prominent divisions, distinguished by the organs of the mouth, the eyes and general habit, the Gammarus and Hyperia sections, as laid down by Edwards. The addition of the Læmipoda to the Amphipoda introduces a third division. The sections are hence:—

Subtribus I. Caprellidea.—Maxillipedes elongati, palpiformes. Caput oculique mediocres. Abdomen obsolescens.

Subtribus II. Gammaridea.—Maxillipedes elongati, palpiformes. Caput oculique mediocres. Abdomen appendicibus sex natatoriis sexque styliformibus instructum.

Subtribus III. Hyperidea.—Maxillipedes abbreviati, lamellati, operculiformes. Caput grende, oculorum corneis plerumque tectum. Appendices abdominales ac in *Gammarideis*, latius lamellatæ.

The Caprellidea have the habit of certain of the Anisopoda, and their short abdomen calls to mind the Isopoda. They therefore properly stand first among the Amphipoda. The Caprellids like the species of Arcturus and Tanais, cling and stand upon seaweeds, etc., by their six hinder legs, while the body and the other legs are extended, for the purpose of capturing their food and conveying it to the mouth.

In the following synopsis of the Families, Subfamilies and Genera, some new genera are included, discovered by the author in the course of the cruise of the Exploring Expedition under Capt. Wilkes.

TRIBUS I.

ISOPODA.

Subtribus I. IDOTÆIDEA.*

Fam. I. IDOTÆIDÆ.

Pedes fere consimiles, plus minusve ambulatorii.

G. 1. Idotæa, *Fabr.*—Antennæ externæ longiores, flagello multiarticulato confectæ.
G. 2. Edotea, *Guerin.*—Antennæ externæ internis parce longiores, flagello pauciarticulato confectæ, basi paulo longiore quam basis internarum.
G. 3. Erichsonia, *Dana.*—Antennæ externæ internis multo longiores, geniculatæ, 6-articulatæ, flagello carentes. Pedes subæqui consimiles.
G. 4. Cleantis, *Dana.*—Antennæ externæ multo longiores, 5–6-articulatæ, non geniculatæ, flagello carentes. Pedes 4ti 3tiis valde breviores, et 4ti 5ti 6ti 7mi longitudine sensim increscentes. Abdominis opercula laminam appendiculatam ad articulationem gerentia.
G. 5. Epelys, *Dana.*—Antennæ breves, longitudine subæquæ; externæ flagello carentes, non geniculatæ. Pedes subæqui.

Fam. 2. CHÆTILIDÆ.

Pedes 6ti longissimi, setiformes et multi-articulati.

G. 1. Chætilia, *Dana.*—Antennæ 1mæ longiores, superiores, 2dæ flagello multiarticulato confectæ. Pedes 7mi breves, non unguiculati. Abdominis opercula laminam appendiculatam ad articulationem gerentia.

* The genera *Erichsonia*, *Cleantis*, *Epelys* and *Chætilia*, are described by the author in this Journal, [2,] viii, 424, 1849.

Subtribus II. ONISCOIDEA.

Fam. I. ARMADILLIDÆ.*

Corpus bene convexum, stricte articulatum. Abdomen multi-articulatum, segmento ultimo parvo. Appendices caudales† ultra abdomen non exsertæ, lamellatæ. Mandibulæ non palpigeræ. Antennæ internæ inconspicuæ.

Subfam. 1. TYLINÆ.‡—Appendices caudales infra abdominis segmentum posticum celatæ et operculiformes.

G. 1. TYLUS, *Latreille.*

Subfam. 2. ARMADILLINÆ.§—Appendices caudales inter duo abdominis segmenta postica partim visæ.

G. 1. ARMADILLO,‖ *Latr.*, partim, *Brandt, Edw.*—Basis appendicum caudalium grandis, ramo interno parvulo, altero obsoleto.

G. 2. SPHÆRILLO, *Dana.*—Basis appendicum caudalium grandis, ramo interno parvulo, externo parvulo, in latere basis interiore versus apicem insito.

G. 3. ARMADILLIDIUM,¶ *Brandt.*—Basis appendicum caudalium brevis, ramo extorso lato, terminali, interno parvulo.

G. 4. DIPLOEXOCHUS, *Brandt.*—*Armadilloni* appendicibus caudalibus similis. Segmenta thoracis processu horizontali utrinque armata.

Fam. II. ONISCIDÆ.

Corpus sæpius minus convexum, vel stricte vel laxe articulatum. Abdomen multi-articulatum, segmento ultimo parvo. Appendices caudales valde exsertæ, styliformes. Mandibulæ non palpigeræ. Antennæ internæ inconspicuæ.

Subfam. 1. ONISCINÆ.**—Maxillipedes 3-articulati, articulis duobus ultimis brevibus et parvulis. Antennæ externæ ad articulationem 5tam bene geniculatæ. Basis appendicum caudalium perbrevis, duos stylos multum inæquos gerens, stylo interno sub abdomine partim celato.

G. 1. ONISCUS, *Linn.*—Antennæ externæ subcylindricæ, ad basin fronte partum tectæ. Flagellum 1–3-articulatum,†† articulo precedente vix brevius vel longius.

Subgen. 1. TRICHONISCUS, *Brandt.*‡‡—Antennæ externæ 6-articulatæ.
Subgen. 2. PORCELLIO, *Latr*—Antennæ externæ 7-articulatæ.
Subgen. 3. ONISCUS, *Latr.*—Antennæ externæ 8-articulatæ.

G. 4. PHILOSCIA. *Onisco* affinis. Antennæ externæ usque ad basin apertæ, 7-articulatæ, subcylindricæ. Flagellum ac in *Porcellione.*

G. 5. PLATYARTHRUS, *Brandt.*—Antennæ externæ quoad articulum 5tum latæ, latere externo dilatatæ.

G. 6. DETO, *Guerin.*—Flagellum antennarum externarum perbreve, 4-articulatum, articulo precedente multo brevius, articulo 5to cylindrico.

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* *Armadillidæ*, Koch, Deutschl. Crust., 34th Heft, 1840; also Cat. Brit. Crust. Brit. Mus, 1850, p. 73.

† Appendices normales abdominis 6tæ nobis denominatæ *appendices caudales*; segmentum abdominis ultimum *segmentum caudale* est.

‡ *Tylosiens*, Edw.

§ *Armadilliens*, Edw.

‖ *Pentheus*, Koch.

¶ *Armadillo*, Koch, et Latr. partim.

** *Porcellioniens*, Edw. *Porcellionidæ*, Cat. Brit. Crust. Brit. Mus., 1850. We deem it better to derive the family name from the *older* generic name, Oniscus.

†† Præter hos tres articulos, flagellum articulis minutis 1–3 inconspicuis ad extremitatem confectum, ultimo styliforme et apice setigero.

‡‡ *Itea*, Koch.

Subfam. 2. SCYPHACINÆ.—Maxillipedes 2-articulati, articulo 2do lamellato. Antennæ externæ ad articulationem 5tam non geniculatæ. Styli caudales ac in *Oniscinis*. Basis appendicum caudalium aut brevis aut oblongus, ramo interno interdum omnino aperto.

G. 1. SCYPHAX, *Dana*.—Flagellum antennarum 1–3-articulatum.
G. 2. STYLONISCUS, *Dana*.—Flagellum antennarum tenue, multi-articulatum.

Subfam. 3. LYGINÆ.—Maxillipedes 4-articulati, elongati. Antennæ externæ ad articulationem 5tam non bene geniculatæ. Styli caudales longi, basi longè exserto, ramis setiformibus, subæquis et æque apertis.

G. 1. LYGIA, *Fabr.*—Basis appendicum caudalium apice simplex, ramosque duos simul gerens.
G. 2. LYGIDIUM, *Brandt.**—Basis appendicum caudalium apice furcatus, brachio utroque ramum setiformem gerente.

Fam. 3. ASELLIDÆ.

Corpus sæpius plus depressum et laxè articulatum. Abdomen 6-articulatum, segmento ultimo grandi, scutellato. Appendices caudales styliformes, interdum brevissimæ. Mandibulæ palpigeræ. Antennæ internæ conspicuæ.

Subfam. 1. LIMNORINÆ.—Abdomen 5–6-articulatum.

G. 1. LIMNORIA.—Segmenta abdominis duo postica grandia, simul sumta scutellata.

Subfam. 2. ASELLINÆ.—Abdomen 1–2-articulatum.

1. *Pedes thoracici subæqui.*

G. 1. JÆRA, *Leach*.—Appendices caudales perbreves; branchiales laminâ impari tectæ.
G. 2. JÆRIDINA, *Edw.*—Appendices caudales perbreves; branchiales apertæ.
G. 3. ASELLUS, *Geoffroy*.—Appendices caudales elongatæ. Pedes antici subchelati.
G. 4. JANIRA, *Leach.*†—*Asello* affinis. Pedes toti unguiculati, ungue bifido.
G. 5. HENOPOMUS, *Kröyer.*‡—Pedes 1mi subchelati, digito 2-articulato; reliqui ambulatorii, articulo 6to sub-rudimentario. Appendices branchiales laminâ unicâ permagnâ tectæ. Thoracis segmenta latere incisa et dentata.

2. *Pedes posteriores valde elongati.*

G. 6. MUNNA, *Kröyer.*§—Appendices caudales rudimentariæ. Pedes antici crassiores, subchelati; posteriores corpore multo longiores.

Subtribus III. CYMOTHOIDEA.

[The Cymothoidea correspond nearly to the *Isopodes nageurs* of Edwards.‖ The subtribe thus embraces along with Edwards's "Cymothoadiens" (Serolis excluded) his "Spheromiens." The *Cymothoa*, *Æga* and *Spheroma* sections are closely related, and constitute a single natural group. The *first* (*Cymothoidæ*) has the antennæ attached to the under surface of the head somewhat remote from the front margin, and the caudal stylets are free; the *second* (*Ægidæ*) has the antennæ

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* *Zia*, Koch.
† *Oniscoda*, Latreille.
‡ Nat. Tidsskr., [2], ii, 1847.
§ Ibid. ii, 1838, 1839, p. 612 and [2], ii, 1847.
‖ The exceptions consist in our removal of his *Pranisiens*, and the genus *Serolis*, to the Anisopoda.

attached to the front of the head, with the caudal stylets free; the *third* (*Spheromidæ*) has the antennæ attached to the front of the head, with the inner lamina of the caudal stylets united to the abdomen. In the Cymothoidæ, the legs are all ancoral and the caudal stylets and branchiæ are not ciliated; in the Ægidæ and Spheromidæ, only the two or three anterior pairs of legs are ancoral, if any, and the caudal stylets and branchiæ are commonly ciliated. A single genus of the Cymothoidæ (*Ægathoa*) has the habit of Ægа and ciliated caudal stylets, with the antennæ and ancoral legs of Cymothoa. This ciliation of the lamellar abdominal appendages appears to be a mark of degradation in the species, and is strikingly characteristic of the abdominal natatory feet of the Amphipoda. The family Ægidæ contains two groups, distinct in habit; one (*Æginæ*) often parasitic, having the 6 anterior legs ancoral, the other (*Cirolaninæ*) not parasitic, and with none of the legs ancoral.]

Fam. I. CYMOTHOIDÆ.*

Maxillipedes breves, 3–4-articulati, operculiformes, articulis terminalibus angustis brevibus. Appendices caudales liberæ, marginibus rarissimè ciliatæ. Antennæ sub capite infixæ. Abdomen 4–6-articulatum, segmentis anterioribus raro connatis. Pedes toti ancorales. Branchiæ sæpissime non ciliatæ. Epimeræ conspicuæ.

Subfam. 1. CYMOTHOINÆ.—Lamellæ caudales nudæ. Abdomen multiarticulatum, segmentis liberis.

G. 1. CYMOTHOA, *Fabr.*—Femora lata, posteriora latissima. Segmenta thoracis 2 3ve postica multo breviora nunquam latere acutè producta. Segmentum caudale sæpissimè valde transversum. Antennæ graciles; 1mæ ad basin paulo remotæ.

G. 2. CERATOTHOA,† *Dana.*—*Cymothoæ* affinis. Antennæ 1mæ crassæ basi conjunctæ. Caput postice latum, fronte productum et sæpe angustum.

G. 3. LIVONECA, *Leach.*—Femora latiuscula, 6ta vel 7ma 5tis vix latiora, non angustiora. Segmenta thoracis 3tium 4tum 5tum 6tumque fere æqua, 7mum paulo brevius. Abdomen thorace subito vix angustius. Caput parvulum. Frons non involutus et in processum inter-antennalem conspicue non productus. Segmentum caudale vix transversum. [Corpus sæpe oblique distortum.]

G. 4. ANILOCRA, *Leach.*—Femora angusta, posteriora angustiora. Segmentum thoracis 2dum 3tium 4tumve 5to 6to 7move multo brevius. Abdomen thorace subito angustius, segmentis processu laterali spiniformi infra non instructis, ultimo vix transverso.

Subgen. 1. ANILOCRA.—Rami appendicis caudalis multo inæqui.
Subgen. 2. CANOLIRA, *Leach.*—Rami appendicis caudalis subæqui.

G. 5. NEROCILA, *Leach.*—Femora et segmenta thoracis ac in *Anilocrâ*. Abdomen thorace subito angustius, segmentis processu laterali spiniformi infra instructis, ultimo vix transverso.

G. 6. OLENCIRA, *Leach.*—Femora latitudine mediocria. Segmenta thoracis 3 postica anterioribus non longiora. Abdomen thorace subito multo angustius, segmentis cum processubus spiniformibus infra non instructis, ultimo non transverso.

Subfam. 2. OROZEUKTINÆ.—Segmentum abdominis posticum ac in *Cymothoâ*; segmenta alia coalita et non libera.

G. 2. OROZEUKTES, *Edw.*

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* *Cymothoadiens Parasites*, Edw. Crust., iii, 228, 247.
† *Cymothoa Gaudichaudii* et *C. parallela* hîc pertinent.

Subfam. 3. ÆGATHOINÆ.—Lamellæ caudales ciliatæ. Abdomen inviti articulatum, segmentis liberis.

G. 1. ÆGATHOA, *Dana*.—Abdomen thorace subito non angustius, segmentis subæquis. Caput subtriangulatum, latum, thorace parce angustius. Oculi grandes.

Fam. II. ÆGIDÆ.*

Maxillipedes elongati, 4–6-articulati, articulis totis lamellatis, terminalibus latis et brevibus. Appendices caudales liberæ, marginibus ciliatæ. Antennæ ad frontis marginem capitis affixæ, apertæ. Abdomen 4–6-articulatum. Pedes 6 antici interdum ancorales aut prehensiles, sæpius simpliciter unguiculati, 8 postici unguiculati et nunquam ancoraies. Branchiæ ciliatæ. Epimeræ conspicuæ.

Subfam. 1. ÆGINÆ.—Pedes 6 antici ancorales, unguibus validis; reliqui unguibus parvulis confecti.

G. 1. ÆGA, *Leach*.—Pedes 6 antici æque ancorales. Antennæ 1mæ basi contiguæ, 2dæ per epistomatis processum sejunctæ. Frons capitis non saliens.

Subgen. 1. ÆGA.—Oculi remoti. Antennæ 1mæ basi complanatæ.
Subgen. 2. CONILERA, *Leach*.—Oculi remoti. Antennæ 1mæ basi subcylindricæ.
Subgen. 3. ROCINELA, *Leach*.—Oculi grandiores, inter se contiguæ. Antennæ 1mæ basi complanatæ.

G. 2. ACHERUSIA, *Lucas*.†—*Ægæ* affinis. Antennæ 2dæ per processum non sejunctæ. Frons capitis saliens.

G. 3. PTERELAS, *Guerin*.—*Ægæ* affinis. Pedes 2di 3tii sæpeque 1mi subdidactyli, processu e articulo penultimo instar digiti immobilis, processu sive acuminato sive acie instructo.

Subfam. 2. CIROLANINÆ.—Pedes nulli ancorales.

G. 1. CIROLANA, *Leach*.‡—Segmenta thoracis subæqua. Pedes unguibus parvulis confecti. Antennæ 2dæ per processum epistomatis tenuem sejunctæ. Abdomen 6-articulatum.

G. 2. CORALLANA, *Dana*.—Segmenta thoracis subæqua. Pedes unguibus parvulis confecti. Antennæ 2dæ epistomate transverso latissimè sejunctæ et partim tectæ, epistomate antennisque 1mis latè conniventibus.

G. 3. ALITROPUS, *Edw*.—Segmenta thoracis 3 postica anterioribus longiora, ac in *Nerocila*. Pedes unguibus crassiusculis confecti.

Fam. III. SPHEROMIDÆ.§

Maxillipedes elongati 5–6-articulati et palpiformes. Appendices caudales margini abdominis laterali conjunctæ. Antennæ ad frontis marginem capitis affixæ, apertæ. Abdomen 1–2-articulatum. Pedes non ancorales (raro 4 antici ancorales). Branchiæ ciliatæ. Epimeræ non distinguendæ.

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* *Cymothoadiens errans*, Edw. Crust., iii, 233.—*Ægidæ*, Cat. Brit. Crust. Brit Mus., 1850, p. 78.

† Expl. de l'Algiers, pl. 8, f. 3.

‡ Genera *Eurydice* et *Nelocira*, Leach, inclusa cum Cirolaná. Eurydice discrepat abdomine 5-articulato tantum.

§ *Spheromiens onguiculés*, Edw. Crust., iii, 199.—*Spheromidæ*, Cat. Brit. Crust. Brit. Mus., 1850, p. 75.

Subfam. 1. SPHEROMINÆ.—Lamella appendicis caudalis externa sub internâ se latens.

1. *Corpus in globum contractile.*

G. 1. Spheroma, *Latr.*—Lamellæ appendicis caudalis subæquæ.

2. *Corpus in globum non contractile.*

G. 2. Cymodocea, *Leach, Edw.**—Caput valde transversum, multo convexum. Lamellæ appendicis caudalis subæquæ.

G. 3. Cerceis, *Edw.*—Caput parce transversum, subtriangulatum, vix convexum. Antennæ 1mæ quoad basin capite tectæ, processu non sejunctæ.

G. 4. Cassidina, *Edw.*—Corpus latum; caput valde transversum. Lamellæ appendicis caudalis angustæ, valde inæquæ, externâ parvulâ. Antennæ 1mæ quoad basin processu frontis sejunctæ.

G. 5. Amphoroideum, *Edw.*—Antennæ quoad basin lamellate portentose productæ ultra capitis frontem.

Subfam. 2. NESÆINÆ.—Lamella appendicis caudalis externa saliens, sub internâ se non latens, usquam aperta. Pedes nulli ancorales.

G. 1. Nesæa, *Leach, Edw.*†—Lamella caudalis externa recta.

G. 2. Campecopea, *Leach.* Lamella caudalis externa arcuata.

Subfam. 3. ANCININÆ.—Pedes 4 antici ancorales.

G. 1. Ancinus, *Edw.*—Appendices caudales unâ lamellâ oblongâ saliente basique brevissimo instructæ.—An tribus Anisopodorum est genus Ancinus?

TRIBUS II.

ANISOPODA.

Subtribus I. SEROLIDEA, vel Anisopoda Cymothoica.

Fam. I. SEROLIDÆ.

Appendices abdominales sex anticæ liberæ, subnatatoriæ, quatuor sequentes branchiales, bene lamellatæ, ultimæ ac in *Cymothoadis*. Antennæ 1mæ sub capite insitæ.

G. 1. Serolis, *Leach.*

Fam. II. PRANIZIDÆ.‡

Appendices abdominales totæ ac in *Ægidis*. Antennæ 1mæ sub capite insitæ. Pedes thoracis numero decem, paribus duobus anticis rudimentariis. Thoracis segmenta numero quinque non superantia.

Subfam. 1. PRANIZINÆ.—Caput parvum. Mandibulæ vix salientes.

G. 1. Praniza, *Leach.*

Subfam. 2. ANCEINÆ.—Caput grande. Mandibulæ ultra caput longè exsertæ.

G. 1. Anceus, *Risso.*

Subtribus II. ARCTURIDEA, vel Anisopoda Idotæica.

Fam. I. ARCTURIDÆ.

Subfam. 1. ARCTURINÆ.—Opercula abdominis ad ventrem stricte appressa.

* Genus *Dynamena*, Leach, is included. † Genus *Cilicæa*, Leach, is included.

‡ *Pranisiens*, Edw. Crust. iii, 92.

G. 1. Arcturus, *Latr.*—Segmenta thoracis subæqua. Antennæ 2dæ flagello longo confectæ.

G. 2. Leachia, *Johnston.*—Segmentum thoracis 4tum prælongum. Antennæ 2dæ longæ, ungue 1–3-articulato confectæ. Pedes 8 antici ciliati, non unguiculati.

Subfam. 2. ANTHURINÆ.—Opercula abdominis ad ventrem non bene appressa, sed libera et latera abdominis partim tegentia.

G. 1. Anthura, *Leach.*—Antennæ breves, 4–8-articulatæ. Pedes antici subchelati.

Subtribus III. TANAIDEA, vel Anisopoda Oniscica.

Fam. 1. TANAIDÆ.

Pedes 1mi 2dive subchelati, sequentes non ancorales. Abdomen paribus 5 appendicum subnatatoriis unoque postico stylorum instructum.

Subfam. 1. TANAININÆ.—Corpus lineare, segmento thoracis 1mo sæpe oblongo capiteque parvulo. Styli caudales longo.

G. 1. Tanais, *Edw.**—Antennæ 1mæ flagello non confectæ. Pedes antici breves, crassè chelati, reliqui unguiculati. Styli caudales sat longi, 3–7-articulati, simplices.

G. 2. Paratanais, *Dana.*—*Tanai* similis. Styli caudales biramei, ramis inæquis, articulis uno vel pluribus instructis. Pedes antici breves.

G. 3. Leptochelia, *Dana.*†—Antennæ 1mæ longæ, flagello confectæ. Pedes antici longi, digitis hiantibus; reliqui unguiculati. Styli caudales sat longi, articulati, ramo laterali instructi.

G. 4. Apseudes, *Leach.*—Antennæ 1mæ 2dæque flagello unico confectæ. Pedes antici breves, crassè chelati, 2di extremitate laminati, non unguiculati.

G. 5. Rhœa,‡ *Edw.*—Antennæ 1mæ 2dæque flagello confectæ, 1mis quoque flagello appendiculari. Pedes 1mi 2dique crassi, 1mis chelatis, 2dis unguiculatis.

Subfam. 2. LIRIOPININÆ.—Corpus antice latius, postice sensim angustans, segmento thoracis 1mo reliquis vix longiore, capite sat grandi. Appendices abdominales numero decem elongatæ.

G. 1. Liriope, *Rathke.*§—Pedes 4 antici subprehensiles, 5ti 6tique unguiculati, 7mi abbreviati, articuloque styliformi confecti. Antennæ 1mæ perbreves [setarum scopulâ ornatæ].

G. 2. Cryptothir, *Dana.*—*Liriopi* affinis. Pedes 7mi non abbreviati, unguiculati.

Subfam. 3. CROSSURININÆ.—Corpus antice latius, postice sensim angustatum, segmento thoracis 1mo vix longiore, capite sat grandi. Appendices abdominales inferiores numero sex, ciliatæ.

G. 1. Crossurus, *Rathke.*‖—Pedes antici chelati, robusti, reliquis unguiculatis. "Abdomen duabus tæniis semicircularibus e magno pilorum erectorum numero compositis fimbriasque duas exhibentibus cinctum."

Fam. II. BOPYRIDÆ.¶

Pedes toti plerumque aliquo modo subprehensiles vel ancorales. *Maris*, corpus angustum, abdomen 1–6-articulatum, appendicibus subnatatoriis stylisque duobus sæpe instructum, interdum totis appendicibus obsoletis; *feminæ*, corpus latum et obesum, oculis carens, et quoad pedes sæpe partim obsoletum.

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* Genus *Zeuxo*, Templeton, (Trans. Ent. Soc., ii, 203,) is included.

† Amer. J. Sci. [2], iii, 425, 1849. Here falls *Tanais Edwardsii*, Kr. (Tids. iv, 1842.)

‡ Genus *Triura*, Tellkampf (Archiv. f. Nat., 1844, p. 321) Rhœæ forsan affinis. Styli caudales longissimi et setiformes. Speciei descriptio et icon non bonæ.

§ Faun. Norw., 60, pl. 1, f. 8–12. ‖ Ibid. 35, pl. 1, f. 1–7.

¶ *Epicarides*, Latr.; *Isopodes sedentaires*, Edw. Crust., iii, 277.

Subfam. 1. BOPYRINÆ.—Thorax appendicibus branchialibus carens.

G. 1. Bopyrus, *Latr.*—Pedes thoracis *feminæ* manu imperfectâ confecti. Appendices abdominis branchiales laminatæ, laminâ unicâ compositæ et abdomine tectæ.

G. 2. Phryxus, *Rathke.**—Pedes thoracis *maris* ancorales, *feminæ* manu imperfectâ confecti. Appendices abdominis *feminæ* branchiales magnæ, laminis duabus inæquis nudis compositæ, una vel ambæ laminæ laterales; *maris* rudimentariæ.

G. 3. Cepon, *Duvernoy.*†—Pedes thoracis feminæ non unguiculati, per pulvillum terminalem ancorales. Appendices abdominis *feminæ* branchiales numero duodecim, elongatè lamellatæ et bene ciliatæ.

G. 4. Dajus, *Kröyer.*‡—*Maris* abdomen 6-articulatum, segmento ultimo prælongo; pedes thoracis bene unguiculati; appendices abdominis numero decem, oblongæ, ciliatæ, aliis duabus terminalibus minutis. *Feminæ* appendices abdominis laterales, duæ posticæ caudales breves, exsertæ.

Subfam. 2. IONINÆ.—Pedes thoracis ad basin appendices simplices branchiales gerentes.

G. 1. Ione, *Latr.*—Pedes thoracis manu imperfectâ confecti. Appendices abdominales laterales, *maris* tenuiter cylindricæ, *feminæ* ramosæ præter duas ultimas simplices.

G. 2. Argeia, *Dana.*—Pedes thoracis manu imperfectâ confecti. Appendices *feminæ* abdominales laterales, birameæ, ramis simplicissimis, nudis; *maris* nullis, abdomine non articulato, nudo.

TRIBUS III.

AMPHIPODA.

Subtribus I. CAPRELLIDEA.

Fam. 1. CAPRELLIDÆ.

Corpus longum et fere filiforme. Antennæ 2dæ longitudine mediocres. [Species non parasiticæ.]

1. *Pedes thoracis numero* 14.

G. 1. Proto,§ *Leach.*—Mandibulæ palpigeræ. Branchiæ segmentis 2do 3tio 4toque affixæ. Pedes thoracis toti articulis normales.

G. 2. Protella, *Dana.*—Mandibulæ palpigeræ. Branchiæ segmentis 3tio 4toque affixæ. Pedes 3tii 4tique obsoleti articulo 1mo styliformi excepto.

2. *Pedes thoracis 3tii 4tique omnino obsoleti.*

G. 3. Caprella, *Lamk.*—Mandibulæ non palpigeræ. Branchiæ segmentis thoracis 3tio 4toque affixæ. Abdomen brevissimum, 1–2-articulatum.

G. 4. Ægina, *Kröyer.*‖—Mandibulæ palpigeræ, palpis 3-articulatis. Branchiæ ac in *Caprellâ*. Abdomen brevissimum, 1–2-articulatum.

G. 5. Cercops, *Kröyer.*¶—Mandibulæ palpigeræ. Branchiæ segmentis 2do 3tio 4toque affixæ. Abdomen 5-articulatum, appendicibus 4 elongatis 3-articulatis.

3. *Pedes 3tii 4ti 5tique obsoleti.*

G. 6. Podalirius, *Kröyer.***—Branchiæ segmentis 3tio 4toque affixæ.

Fam. 2. CYAMIDÆ.

Corpus latum, depressum. Antennæ 2dæ obsoletæ. [Species parasiticæ.]

G. 1. Cyamus.

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* Fauna Norwegens, p. 40.
† Annales des Sci. Nat. [2], xv, 110, pl. 4.
‡ Voy. Scand., etc., Crust. tab. 28, 29.
§ *Leptomera*, Latreille.
‖ Tids. iv, 1842.
¶ Ibid.
** Voy. Scand., pl. 25, and Tids. [2], i, 283.

Subtribus II. GAMMARIDEA.

[Among the Gammaridea, the author finds that the posterior caudal stylets offer important characters for distinguishing natural groups or genera, and upon this ground, some new genera have been recognized among the Corophidæ and Gammaridæ, and others *that have been rejected* are sustained. Thus *Iphimedia* is distinct from *Amphithoe*, *Mæra* and *Dercothoe* from *Gammarus*, etc.]

Fam. I. DULICHIDÆ.

Gressoriæ, habitu Caprelloideæ. Corpus lineare, epimeris obsoletis. Pedes posteriores longi, subprehensiles. Abdomen 5-articulatum.

G. 1. DULICHIA, *Kröyer.**—Pedes 5ti 6ti 7mique, subæqui, 2di manu confecti. Antennæ quatuor longæ, superiores prælongi.

Fam. II. CHELURIDÆ.

Corpus fere cylindricum, epimeris mediocribus. Abdomen segmentis 4to 5toque coalitis et oblongis, stylis inter se valde dissimilibus.

G. 1. CHELURA, *Philippi.*†

Fam. III. COROPHIDÆ.

Gressoriæ, pedibus partim lateraliter porrectis. Corpus plus minusve depressum, sæpe latum, epimeris perbrevibus, interdum obsoletis. Abdomen formâ appendicibusque normale. Antennæ sæpe pediformes.

Subfam. 1. CLYDONINÆ.—Styli caudales sex simplices, subulati.

G. 1. CLYDONIA, *Dana.*‡—Pedes filiformes, 5ti 6ti 7mique, longitudine increscentes, 1mi 2di non prehensiles. Antennæ duæ longæ, crassæ, rigidæ.

Subfam. 2. COROPHINÆ.—Antennæ plus minusve pediformes. Styli caudales 1mi 2dique biramei.

A. DIGITUS NULLUS 2-ARTICULATUS.

1. *Styli caudales 3tii minuti, simplices, 2di 1mique ramo externo cultriformi.*

G. 1. COROPHIUM, *Latr.*—Antennæ inferiores longiores et crassiores, flagello carentes. Pedes 2di non prehensiles, 1mis crassiores, articulo 4to latiore quam 5tus.

G. 2. SIPHONŒCETES, *Kröyer.*§—Antennæ inferiores longiores, flagello carentes. Pedes 1mi 2dique subchelati. [Pedes 3tii 4tique articulo 4to laté obcordato. Tubum lapillis fragmentisque concharum formatum inhabitat.]

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* Tids. [2], i, 512, 1845.

† Arch. f. Nat. 1839; and G. J. Allman, Ann. and Mag. N. H. xix, 361, June, 1847.

‡ Amer. J. Sci. [2], viii, 140; *Icilius*, D., on same page.

§ Voy. Scand., etc., 1838–1840, pl. 20, f. 1; Tidsskr. [2], i, 481, 1845. Kröyer in his description says:—

"Pedes thoracici primi et 2di paris validissimi, manu instructi subcheliformi. Pedes 3tii et 4ti paris articulo primo latissimo, laminari; articulo quarto obcordato, laminari, manum præbente, cujus unguis efficitur articulo quinto subconico articuloque sexto aciculari. Pedes 5ti 6tique paris minutissimi, sed robusti, recurvati, articulo primo clavato, ungue furcato. Pedes 7mi paris graciles, recurvati, articulo primo laminari, ungue minutissimo, furcato. Pedes abdominales 1mi, 2di et 3tii paris natatorii breves validissimi, parte basali latissima, rhomboidali; pedes 4ti, 5tique paris saltatorii, pes abdominalis sexti paris natatorius unica instructus lamina terminali."

2. *Styli caudales 3tii minuti, vix exserti, simplices, 2di 1mique ramis extus non præcipue spinosis nec cultriformibus, interdum nudis.*

G. 3. Platophium, *Dana.*—Corpus superne visum subellipticum, abdomine bene inflexo. Antennæ flagello brevi sæpe instructæ, inferiores longiores, superiores appendiculatæ. Pedes 1mi 2dique subchelati, 2dis validioribus. Pedes 10 postici mediocres.

G. 4. Cyrtophium, *Dana.—Platophio* similis. Antennæ superiores non appendiculatæ.

3. *Styli caudales 3tii parvuli, biramei, ramo externo non uncinato, 2di 1mique ramis extus non præcipue spinosis nec cultriformibus.*

G. 5. Unciola, *Say.**—Pedes 1mi 2dique manu confecti, 1mis validioribus. Antennæ flagellis confectæ, subpediformes, validæ, superiores paulo longiores, appendiculatæ.

4. *Styli caudales 3tii paulo elongati, biramei, ramo externo uncinato.*

G. 6. Podocerus, *Leach.*†—Pedes 1mi 2dique subchelati, 2dis validioribus. Antennæ superiores breviores, non appendiculatæ. [An maris digitus 2dus interdum 2-articulatus Kröyero teste.]

G. 7. Cratophium, *Dana.*—Pedes 1mi 2dique subchelati, 2dis validioribus. Antennæ superiores breviores, appendiculatæ.

B. digitus 2dus 2-articulatus.

G. 8. Cerapus, *Say.*—Antennæ pediformes, subæquæ, flagellis carentes. Pedes 1mi 2dique prehensiles, 1mis parvulis, 2dis manu bene confectis. Styli caudales 3tii biramei, ramis subæquis, longiusculis. [Tubum membranaceum inhabitat.]

G. 9. Cerapodina, *Edw.* (*Cerapus*, Templeton). Antennæ totæ flagellis confectæ. Pedes 4ti 5ti 6tique obsoleti (?) [Tubum papyraceum inhabitat.]

G. 10. Erichthonius, *Edw.*‡—Antennæ flagellis confectæ. Pedes 10 postici mediocres. Epimeræ anteriores obsoletæ. [An styli caudales 3tii simplicissimi?]

Subfam. 3. ICILINÆ.—Antennæ non pediformes nec subpediformes, flagellis sat longis basique sat brevi instructæ. Styli caudales ac in *Corophinis.*

G. 1. Icilius, *Dana.*—Pedes toti unguiculati et tenues, 4 antici longi, non prehensiles, ciliati, 10 postici fere similes. Antennæ superiores breviores non appendiculatæ.

G. 2. Pterygocera, *Latr.*—Pedes posteriores sublamellati. Antennæ superiores breviores, appendiculatæ, inferiores basi dilatatæ.

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* Jour. Acad. Nat. Sci. Philad., i, 388.

Glauconome of Kröyer has the hands and antennæ and apparently the other characters of Unciola. Say describes the hands of the 2nd pair in Unciola as *adactyle;* but they still are probably like those of Glauconome. The following is Kröyer's description:—

"*Antennæ* subpediformes; superiores flagello ornatæ appendiculari perparvo. *Oculi* minuti, parum distincti. *Maudibulæ* apex in duos fissus ramos qui dentibus sunt armati conicis; tuberculus molaris dentibus confertissimis instructus. *Labium superius* breve, depressum latissimum, margine anteriori medio inciso; *labium inferius* quatuor compositum laminis setosis. *Laminæ maxillares* pedum maxillarium dentibus armatæ validis; unguis palpi apice setosus. *Pes primi paris* robustissimus, manu subcheliformi; pes *secundi* paris gracilior, manu carens subcheliformi, pedes 3tii, 4tique paris pergraciles; pedes 5ti, 6ti, 7mique paris graciles femoribus parum dilatatis. Pedes abdominales 1mi 2di et 3tii paris natatorii, breves sed robustissimi; 4ti, 5tique paris saltatorii, validi; 6ti paris fere rudimentares, natatorii. Epimera minima fere evanescentia."

† *Jassa* of Leach may without inconvenience be united to *Podocerus*, as there is no essential generic difference between them.

‡ The author obtained three species in the cruise of the Expedition having the hands and many other characters of Erichthonius, but with the epimerals of the anterior thoracic segments of considerable size; and moreover no gressorial habits were observed. They are therefore with some hesitation arranged in a genus named Pyctilus, among the Gammaridæ, subfamily Gammarinæ.

Fam. IV. ORCHESTIDÆ.*

Saltatoriæ, pedibus nullis lateraliter porrectis. Corpus compressum, epimeris magnis. Abdomen appendicibus normale. Antennæ non bene pediformes. Styli caudales 1mi 2dique biramei; 3tii simplices, brevissimi et ultra 2dos non prolongati. Mandibulæ non palpigeræ. Maxillæ 1mæ palpo sive parvulo et 1-articulato sive obsoleto instructæ.

G. 1. ORCHESTIA.—Maxillipedes non unguiculati. Antennæ 1mæ basi 2darum breviores. Epimeræ 5tæ 4tis parce breviores.

Subgen. 1. TALITRUS.—Pedes 1mi *maris femineæve* manu non instructi.
Subgen. 2. TALORCHESTIA, *D.*—Pedes 1mi *maris* ac in *Talitro*, *feminæ* manu parvulâ instructi.
Subgen. 3. ORCHESTIA.—Pedes 1mi *maris femineque* manu plus minusve instructi.

G. 2. ALLORCHESTES, *Dana.*—Maxillipedes unguiculati. Antennæ 1mæ minores, basi 2darum longiores. Epimeræ 5tæ 4tis sæpius multo breviores.

Fam. V. GAMMARIDÆ.

Saltatoriæ vel natatoriæ, pedibus nullis lateraliter porrectis. Corpus sæpius compressum, raro subdepressum, epimeris sive magnis sive parvis. Styli caudales laxiores, duobus ultimis oblongis sæpiusque ultra 2dos prolongatis, raro simplicibus. Mandibulæ sæpissimè palpigeræ. Maxillæ 1mæ palpo 2–3-articulato (rarissimè 1-articulato) instructæ.

I. PEDES 10 POSTICI NON PREHENSILES.

Subfam. 1. STEGOCEPHALINÆ.—Antennæ breves, superiores basi crassæ. Mandibulæ acie denticulatâ instructæ, palpo brevi uniarticulato intus dentato. Epimeræ permagnæ.

G. 1. STEGOCEPHALUS, *Kröyer.*†—Epimeræ 4tæ maximæ, 5tis parvis. Antennæ superiores appendiculatæ. Pedes 1mi 2di manubus carentes. [Pedes 5ti 3tii 4tique directione similes.]

Subfam. 2. LYSIANASSINÆ.—Antennæ breves, superiores basi crassæ. Mandibulæ apice parce dentatæ, acie vix instructæ, palpo 2–3-articulato. Maxillipedes lamellis internis grandibus. Epimeræ permagnæ.

1. *Pedes 1mi 2dique non subchelati, 2dis parvulis interdum exceptis.*

G. 1. LYSIANASSA, *Edw.*—Antennæ superiores appendiculatæ.
G. 2. PHLIAS, *Guerin.*—Antennæ superiores non appendiculatæ.

2. *Pedes 1mi subchelati, 2dis non subchelatis.*

G. 3. OPIS, *Kr.*‡—Antennæ superiores appendiculatæ. Pedes 1mi crassè chelati, 2di debiles.

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* The author gives a different arrangement of the species of Orchestidæ from that published in this Journal, [2], viii, 135 and ix, 295, and rejects the genus Talitronus there instituted. He follows Fr. Müller (Archiv f. Nat., 1848, 53) in considering the Talitri and Orchestiæ as forming a single genus, his recent investigations confirming this view. The Gammaridæ also are rearranged.

† Kröyer's Nat. Tids. iv, 150, 1842. "Caput oculis ut videtur destitutum."

‡ Tids. iv, 149. "Pedes 1mi paris chelis armati portentosæ magnitudinis. Reliqua cum genere Anonyce ferme convenuint."

G. 4. URISTES, *Dana.**—Antennæ superiores non appendiculatæ. Pedes 1mi subchelati, 2di articulo styliformi confecti.

3. *Pedes 1mi 2dique plus minusve subchelati.*

G. 5. ANONYX, *Kr.*†—Epimeræ permagnæ. Antennæ superiores appendiculatæ, basi breves. Maxillipedes lamellis internis grandibus. Styli caudales postici biramei, ramis subulatis.

G. 6. UROTHOE, *Dana.*—Epimeræ permagnæ, 5tis parvis. Antennæ 1mæ breviores, appendiculatæ, basi sat elongato. Styli caudales postici longi, biramei, ramis foliaceis, ciliatis. Mandibulæ palpo 3-articulato.

Subfam. 3. LEUCOTHOINÆ.—Antennæ superiores basi plus minusve graciles. Maxillipedes elongati, angusti, articulo longo unguiformi confecti, *lamellis internis perbrevibus.* Mandibulæ sive palpigeræ sive non palpigeræ, processu molari carentes. [An semper ?] Epimeræ magnæ.

G. 1. STENOTHOE, *Dana.*—Epimeræ permagnæ, 4tæ maximæ, 5tæ parvulæ. Pedes 4 antici subchelati, 2dis validioribus. Antennæ superiores longiores, non appendiculatæ. Mandibulæ *non palpigeræ, processu molari carentes.* Styli caudales 1mi 2dique ramis bene subulati, 3tii simplicissimi, subulati, spinâ crassâ confecti.

G. 2. LEUCOTHOE, *Leach.*‡—Epimeræ magnæ, 5tæ parvulæ. Pedes 4 antici subchelati, 2dis validioribus. Antennæ superiores longiores, non appendiculatæ. Mandibulæ palpigeræ. Styli caudales toti biramei, ramis subulatis.

[Cujus sedis est *Microcheles*, Kröyer,§ Amphithoe affinis, cui mandibulæ processu molari carentes: quoque *Amphithoe Marionis*, Edw., cui mandibulæ non palpigeræ.]

Subfam. 4. GAMMARINÆ.—Antennæ 1mæ basi graciles. Maxillipedes sat lati, lamellis internis sat elongatis. Mandibulæ acie denticulatâ instructæ et alterâ accessoriâ quoque processu molari et palpo 3-articulato. Pedes 10 postici non subprehensiles.

A. FRONS PRODUCTUS ET INFRA ANTENNIGERUS NON EST, ANTENNIS 1MIS INFERIORIBUS NON ANTERIORIBUS.

1. *Styli caudales postici biramei, ramis subæquis.*

a. PEDES 2DI NON SUBCHELATI.

G. 1. ACANTHONOTUS, *Owen.*—Antennæ quatuor subæquæ, 1mæ non appendiculatæ. Epimeræ magnæ. Pedes 2di filiformes, manu omnino carentes, 1mi manu vix confecti.

G. 2. ALIBROTUS, *Edw.*—Antennæ 1mæ breves, appendiculatæ. Epimeræ magnæ. Pedes 1mi validi non subchelati.

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* Amer. J. Sci. [2], viii, 135. The genus *Stenia* is rejected.

† Tids. ii, 256, and iv, 164.

The genus *Ephippiphora* of White (Ann. and Mag. N. Hist. [2], i, 226, 1848) has been but briefly described, and we cannot pronounce upon its exact relation to either of the genera of Lysianassinæ. The habit is like that of Anonyx, the epimerals large, the superior antennæ appendiculate, the posterior caudal stylets elongate as in Anonyx and not short like the Orchestidæ. But the character of the termination of the 4 anterior legs is not stated, neither are they in view in the figure of the species on plate 5 of the Zool. of the Erebus and Terror. This figure represents the 5th and 6th pair of legs as rudimentary, or the basal joints twice as long as the following part, and the basal joint of the 6th smaller than that of the 5th or 7th.

‡ Kröyer states that the *bi-articulate* finger of Leucothoe is not a true generic characteristic, and adds two species to the genus, one of which has this character imperfectly and the other not at all. (Nat. Tids. iv, 141, 1842, and [2], i, p. 539, 1845). This character of the hand depends mainly on the prolongation of the inferior apex of the antepenult joint, which prolongation is variously developed in species of allied genera. They agree with Leucothoe in their peculiar slender maxillipeds; in the very small epimerals to the 1st segment, large 4th, and small 5th, 6th and 7th; in the caudal stylets; the very short 3d joint of the superior antennæ, and other characters.

§ Tids. N. R. ii, 5.

G. 3. Leptochirus, *Zaddach.**—Antennæ 1mæ appendiculatæ. Pedes 1mi bene subchelatæ, 2di manu carentes.

B. PEDES 2DI IMIQUE SUBCHELATI.

* Antennæ 1mæ non appendiculatæ.

G. 4. Iphimedia, *Rathke*,† *D.*—Epimeræ magnæ, 4tæ maximæ, 5tis multo brevioribus et vix bilobatis. Styli caudales postici ramis duobus oblongis consimilibus apice setigeris et non uncinatis instructi. Antennæ 1mæ sæpius breviores.

G. 5. Œdicerus, *Kröyer.*‡—*Iphimediæ* affinis. Pedes 7mi longissimi, fere filiformes. Antennæ 1mæ breviores.

G. 6. Amphithoe, *Leach*, *D.*§—Epimeræ magnæ, 5tæ maximæ, vix bilobatæ lobo posteriore minimo. Styli caudales postici ramis duobus brevibus dissimilibus instructi, ramo externo apice recurvatim bi-uncinato, interno compresso apice non spinuloso sed pilis parce ciliato. Antennæ 1mæ sæpissime longiores.

** Antennæ 1mæ appendiculatæ.

G. 7. Gammarus, *Fabr.*, *D.*‖—Epimeræ sive mediocres sive breves. Styli caudales postici 2dis non similes, ramis sæpe longis cum pilis raro spinulis ornatis, apice non uncinatis. Antennæ superiores sæpius longiores.

2. *Styli caudales postici sive ramo uno longo altero parvulo instructi, sive simplicissimi et apice non paulo reflexi.*

* Antennæ 1mæ non appendiculatæ.

G. 8. Photis, *Kröyer.*¶—Epimeræ magnæ, 5tæ 4tis non breviores et postice profundius excisæ. Styli caudales ramo interno rudimentario.

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* The genus *Leptochirus*, (Syn. Crust. Borus. Prodromus, 1844) is described by Zaddach as having no appendicular branch to the superior antennæ. But Fr. Muller states (Archiv für Naturgeschichte, 1848, xiv, 62) that there is a small one-jointed appendage in the Leptochirus pilosus. The legs of the 2nd pair are described as having no proper hand, but terminating as in the genus Talitrus. May the form be female only?

† Beit. zur Fauna Norwegens, p. 85, Act. Leop. xx. *Dexamine* of Leach, may perhaps be included here.

The genus *Hyale* of H. Rathke (Fauna der Krym, Mem. Acad. Imp. St. Petersb., iii, 1837, p. 378, pl. 5) contains no characters in its description by this author which do not apply equally well to species of Iphimedia. The description is as follows:—"Corpus elongatum, compressum. Antennæ inferiores superioribus aliquantulum longiores; earum quælibet e tribus articulis atque flagello composita. Oculi disciformes. Pedes 14: duo eorum paria antica chelis monodactylis complanatis, 2di paris multo majoribus. Stylorum abdominalium paria tria. Abdominis appendicula terminalis simplex, erecta, verruciformis." The posterior stylets are 2-branched though short; and the species (H. pontica) is thus distinct from the Allorchestes.

‡ Tids. iv, 155, 1842. "Frons in rostrum producta, plus minus acutum obtusumve, semper vero nodo pellucenti, ovali, flavo-rubescente turgidum. Oculi nulli?" "Pedes 3tii 4tique paris validi, ungue instructi lato laminari, quod quoque usu venit 5to 6toque pari, quorum articulus 1mus dilatatus non est."

§ Includes *Pherusa* of Leach.

‖ *Amathia*, Rathke (Fauna der Krym, Mem. Acad. Imp. St. Petersb., iii, 1837, p. 291, and Beit. zur Faun. Norw. Act. Leop. xx) includes those Gammari that have the superior antennæ the shorter—not a proper basis for a genus. The eye is described as reniform.

The genus *Eusirus* of Kröyer is very near Gammarus, and it is doubtful whether it should be separated. Its habit however is somewhat different. The hands of the 2 anterior pairs of legs are large and equal, and the carpus is articulated with the upper margin of the hand near its middle. The eye is reniform. The superior antennæ have a short appendicular branch, consisting of a minute joint. "Mandibula parva, apice bifurco, dentato, flabello setarum marginis interioris, tuberculo molari transverso-elliptico dentibus minutissimis confectis formato; palpus triarticulatus duplam fere æquat mandibulæ longitudinem. Sex branchiarum paria in maribus (annuli thoracici 2di–7mi), 4 laminarum in feminis paria (annuli 2di–5ti)."—Tids. [2], i, 501.

¶ Tids. iv, 155, 1842, "Pes 5ti paris recurvatus, inversus, ungue rudimentari. Epimera permagna, 5 paria anteriora ad marginem inferiorem setis sat longis instructa, 5tum eadem est ac 4tum altitudine, postice profundius excisum. Lamina terminalis interior pedis saltatorii 3tii paris rudimentaris."

The *inversion* of the 5th pair of legs is not a generic character.

G. 9. Melita, *Leach, D.*—Epimeræ 5tæ 4tis multo breviores (sic an semper?) Styli caudales uno ramo longo, sive subcylindrico sive foliaceo, altero brevi vel obsoleto. [Digitus in manus latus sæpe claudens.] Antennæ 1mæ sæpius longiores.

** Antennæ 1mæ appendiculatæ.

G. 10. Mæra, *Leach, D.*—Epimeræ et styli caudales postici ac in *Melitâ*.

3. *Styli caudales postici simplicissimi, ramo uno brevi et nudo, apice paulo reflexo et spinas duas perbreves paulo exsertas gerente.*

G. 11. Dercothoe, *Dana.*—Epimeræ mediocres, 5tæ bene bilobatæ, 4tis sæpius vix breviores. Pedes 1mi 2dique digito uni-articulato confecti.

G. 12. Pyctilus, *Dana*, (Erichthonius, *Edw.?*)—Epimeræ mediocres vel breves corpore lineari, subdepresso. Antennæ longæ, flagellis sat longis. Manus 1mæ articulis 4to 5toque sæpe instructæ, digito uni-articulato; 2dæ digito 2-articulato.

G. 13. (An hujus sedis?) Pardalisca, *Kröyer.**—Epimeræ breves. Pedes 1mi 2dique digito 2-articulato manuque 1-articulatâ instructi. Antennæ tenues, 1mæ appendiculatæ.

B. frons producta antennasque 1mas versus extremitatem gerens. [an species corophidis affiniores.]

G. 14. Atylus, *Leach.—Iphimediæ* paulo affinis. Antennæ subpediformes, breviores, non appendiculatæ. Digiti 1mi 2dique uni-articulati.

G. 15. Ischyrocerus, *Kröyer.†—Gammaro* paulo affinis. Antennæ pediformes, 1mæ appendiculatæ. Palpus mandibularis longus, articulo ultimo obovato. Pedes 2di *maris* manu validissimâ instructi. Digiti uni-articulati. Epimeræ mediocres.

II. pedes 10 postici partim prehensiles.

Subfam. 5. PONTOPORINÆ.—Pedes 3tii 4tique plus minusve prehensiles; 6 postici non prehensiles.

1. *Antennæ 2dæ inferiores et non posteriores.*

G. 1. Lepidactylis, *Say.‡*—Epimeræ magnæ. Antennæ superiores appendiculatæ, inferiores basi infra valde dilatatæ et partim dolabriformes. Pedes 4 antici filiformes; 3ti 4tique manu compressâ digitoque laminato instructâ; 5ti 6ti 7mique valde compressi, 7mis longioribus, articulis superne valde productis.

G. 2. Pontoporeia, *Kr.§*—Epimeræ magnæ. Antennæ superiores appendiculatæ. Pedes 1mi 2dique perbreves, robusti, 1mi manu latâ ungue brevi confecti, 2di manu carentes; 3tii 4tique validi, manu articulo 4to dilatato instructâ, ungue conico aculeato; 7mi ungue vel articulo 6to rudimentario.

G. 3. Ampelisca, *Kr.‖*—Epimeræ magnæ. Antennæ graciles. Pedes 1mi 2dique manu nullâ subcheliformi; 3tii 4tique manu articulo 3tio instructâ, digito articulis 3 sequentibus formato, articulo ultimo vel ungue longissimo et gracillimo; 5ti 6tique 5-articulati, ungue rudimentario recurvo, immobili (vel parum mobili). Styli caudales postici natatorii.

G. 4. Protomedeia, *Kr.¶*—Corpus subdepressum, epimeris sat brevibus. Antennæ superiores appendiculatæ, inferiores pediformes, basi prælongo. Manus 3tiæ 4tæque articulis 3tio 4toque instructæ et digiti longi articulis sequentibus coalitis. Pedes 2di parvi, manu subcheliformi non instructi.

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* Tids. iv, 153, 1842. "Caput crassiusculum." "Mandibula apice dilatata, quadridentata, palpo 3-articulato." "Pedes 3tii 4tique paris ungue sublaminari postice subtiliter serrulato." "Pedes spurii [abdominales] 2di et 3tii paris natatorii, reliqui saltatorii."

† Tids. iv. "Pedes spurii 4ti 5ti 6tique paris saltatorii; articulus basalis 6ti paris articulis terminalibus triplo vel quadruplo longior."

‡ Jour. Acad. Nat. Sci. Philad., i, 379. Here falls *Bellia* of C. Spence Bate (Ann. and Mag. N. Hist. 1851, [2], vii, 318.)

§ Tids. iv, 152. "Pedes 5ti et 6ti paris recurvi, articulo 1mo parum modo dilatato ungue armati pusillo."

‖ Tids. iv, 154. "Oculi simplices?" "Sextum pedum abdominalium par natatorium."

¶ Tids. iv, 154.

G. 5. Aora, *Kr.**—Corpus subdepressum, epimeris sat parvis. Antennæ superiores longæ, appendiculatæ, inferiores subpediformes. Pedes 1mi 2dique manu subcheliformi, 1mis maximis, articulo 3tio posticè in apicem longissimum producto, manu angustâ, ungue fere lamellari. Manus 3tiæ 4tæque articulo 4to ovali instructæ digitis articulis 5to 6toque. Styli caudales saltatorii, 6tis 7mis setis non aculeis apice instructis.

2. *Antennæ 2dæ multo posteriores, fronte in rostrum producto.*

G. 6. Phoxus, *Kr.*†—Epimeræ permagnæ. Pedes 1mi 2dique manu subcheliformi validâ instructi. Manus 3tiæ 4tæque articulo 3tio 4toque junctis instructæ, digitis 5to 6toque. Pedes 6ti multo longiores. Caput longum, triangulare, antice productum et acuminatum. Antennæ anteriores perbreves (capite breviores), elongate appendiculatæ; posteriores paulo longiores. Mandibulæ palpo longissimo. Segmentum caudale laminis constans duâbus.

Subfam. 6. ISÆINÆ.‡—Pedes quatuor vel sex postici subprehensiles.

G. 1. Isæa, *Edw.*—*Gammaro* similis. Pedes 10 postici similes, articulo 5to apice dilatato et truncato, ungue in articuli 5ti extremitatem latiusculam claudente. Pedes 2di manu grandi confecti. Antennæ superiores appendiculatæ.

G. 2. Anisopus, *Templeton.*—Pedes 4 postici ac in *Isæâ*, validiores, articulo 5to apice inferiore dentato, ungue magno. Pedes 1mi tenues et breves; 2di manu angustâ; 3tii manu grandiore; 4ti 5ti 1mis similes.

Subtribus III. HYPERIDEA.§

[In the first family of the Hyperidea, (the *Hyperidæ*) neither of the 5 posterior pairs of legs are subchelate, and the antennæ are not folded up beneath the head or thorax. In the second, (the *Phronimidæ*,) one or more of the 3 posterior pairs of legs are subchelate or much enlarged, apparently for grasping in coition, and the antennæ are as in the Hyperidæ. The third family (the *Typhidæ*) differs from both the preceding in the concealment and folding of the inferior antennæ beneath the head or thorax, and in many of the species, the abdomen closes up against the venter.]

Fam. I. HYPERIDÆ.‖

Antennæ 2dæ exsertæ. Abdomen in ventrem se non flectens. Pedes 5ti 6ti 7mique formâ longitudineque mediocres, 5tis 6tisve non percrassis nec prehensilibus.

Subfam. 1. VIBILINÆ.¶—Corpus formâ paulo Gammaroideum. Caput oculique mediocres. Maxillipedes palpo parvulo instructi. Palpus mandibularis tenuis.

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* Tids. [2], i, 335, 1845. † Tids. iv, 150.

‡ An genus *Laphystius* (Krŏyer, Tids. iv, 156, 1842) Isæinis vel Corophidis affine. Species in Sturiones Squalosve parasitica! Descriptio sequens:—

Corpus latum, depressum, epimeris mediocribus, 4tis infra acutè productis. Caput transversum, rostratum. Antennæ sat breves, subulatæ, validæ, 1mæ validissimæ, anteriores, 2dæ posteriores. Mandibulæ palpo instructæ. Pedes 1mi gracillimi, manu lineari; 2di breves, manu validâ, ungue sublaminari. Reliqui decem pedes validi, subcheliformes, longitudine subæqui. Styli caudales debiles. Palpus maxillarum 1marum uniarticulatus.

§ *Hyperines* of Edwards, Crust. iii, 70: *Hyperita*, Cat. Brit. Crust. Brit. Mus. 56.

‖ Familiæ duæ nostræ Hyperidæ et Phronimidæ sunt Tribus "Hypérines ordinaires." Edw. (Crust. iii, 74; et *Phronimadæ* Cat. Brit. Crust. Brit. Mus., p. 56.

¶ *Hyperines Gammaroides*, of Edwards, Crust. iii, 72.

G. 1. Vibilia, *Edw.*—Antennæ 4 breves, 1mæ obtusæ. Pedes 1mi 2dique subprehensiles.

Subfam. 2. HYPERINÆ.—Caput tumidum. Oculi pergrandes. Palpus mandibularis tenuis.

1. *Antennæ sive 1mæ sive 2dæ flagello longo confectæ.*

G. 1. Lestrigonus, *Edw.*—Antennæ 1mæ 2dæque flagello longo confectæ. Pedes 1mi 2dique paulo prehensiles.
G. 2. Tyro, *Edw.*—Antennæ 1mæ flagello longo confectæ; 2dæ perbreves, flagello nudo.

2. *Antennæ totæ breves. Caput oculique pergrandes.*

G. 3. Hyperia, *Latr.*—Antennæ 1mæ 2dæque conspicuæ, 2dis gracilioribus. Pedes 2di sæpiusque 1mi subprehensiles, manibus multum imperfectis, articulo 4to ad apicem inferiorem paulo producto tantum.
G. 4. Metoecus, *Kröyer.*—*Hyperiæ* affinis. Pedes 1mi 2diqne perbreves, manibus melioribus bene didactylis confecti.
G. 5. Tauria, *Dana.*—Antennæ ac in *Hyperiâ*. Pedes 2di non prehensiles, articulo 4to apice inferiore non expanso nec producto.
G. 6. Daira, *Edw.*—Antennæ 1mæ non conspicuæ, 2dæ exsertæ. Pedes 1mi 2dique plus minusve prehensiles: tarsi pedum reliquorum breves. Rami stylorum caudalium longi.
G. 7. Cystisoma, *Guèrin.**—Antennis pedibusque 1mis *Dairæ* affine. Tarsi prælongi. Styli caudales longi, ramis brevibus.

Subfam. 2. SYNOPINÆ.—Corpus gracilius. Palpus mandibularis sat brevis, latissimus. Oculi grandes.

G. 1. Synopia, *Dana.*—Caput subtriangulatum, non oblongum. Pigmentum oculorum unicum. Pedes 1mi parvuli, prehensiles; 2di setis longiusculis confecti; 4ti subprehensiles; 5ti 6ti 7mique subæqui.

Fam. II. PHRONIMIDÆ.

Antennæ 2dæ exsertæ. Abdomen in ventrem se non flectens. Pedes 5ti 6tive sive crassi sive elongati, sæpius prehensiles, quoque 3tii 4tique sæpe prehensiles.

Subfam. 1. PHRONIMINÆ.—Abdomen versus basin sat gracile. Pedes 5ti magnâ manu didactylâ vel monodactylâ confecti; 3tii 4ti extremitate graciles, non prehensiles. Antennæ breves.

G. 1. Phronima, *Latr.*—Manus pedis 5ti didactylæ. Segmentum thoracis 1mum oblongum.
G. 2. Primno, *Guèrin.*—Manus pedis 5ti monodactylæ. Segmentum thoracis 1mum non oblongum.

Subfam. 2. PHROSININÆ.—Abdomen versus basin sat crassum. Pedes 5ti prehensiles, monodactyli; quoque 3tii 4tique prehensiles. [Antennæ sat breves.]

1. *Manus pedis 5ti latæ, digito arcuato.*

G. 1. Anchylomera, *Edw.*†—Manus pedis 5ti latè et crassè subtriangulatæ. Pedes 6ti non prehensiles.
G. 2. Phrosina, *Risso.*‡—Manus pedis 5ti latæ, oblongæ. Pedes 6ti prehensiles, 5tis fere similes, minores. Mandibulæ non palpigeræ.

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* Guèrin, Rev. Zool., i, (1842) p. 214. Species *C. neptunus* portentosæ magnitudinis (3½″.)

† *Hieraconyx*, Guèrin.

‡ *Dactylocera*, Latreille.

2. *Manus pedis 5ti elongatè lineares, digito recto, longissimo, tenui.*

G. 3. Themisto, *Guèrin.*—Pedes 3tii 4tique prehensiles, manibus latis.

Subfam. 3. PHORCININÆ.—Pedes 5ti 6tive valde elongati et crassi, sed manu non confecti. [Antennæ breves.]

G. 1. Phorcus, *Edw.*—Pedes 1mi 2di 3tii 4tique graciles, unguiculati, 5ti 6tique prælongi, 5ti aciculares, 6ti crassissimi.

Fam. III. TYPHIDÆ.*

Antennæ 2dæ sub capite thoraceve celatæ et sæpius replicatæ. Abdomen in ventrem sæpe se flectens. Pedes 6 postici interdum abbreviati, articulo 1mo operculiformi, interdum longitudine mediocres.

Subfam. 1. TYPHINÆ.—Abdomen in ventrem se flectens.

G. 1. Dithyrus, *Dana.*—Pedes 5ti 6tique articulo 1mo latè lamellati, articulis reliquis omnino obsoletis. Antennæ 2dæ breves, sub capite celatæ, non replicatæ, articulo 1mo longiore quam 2dus.

G. 2. Typhis, *Risso.*—Pedes 5ti 6tique articulo 1mo late lamellati, articulis reliquis paulo abbreviatis. Antennæ 2dæ biplicatæ, articulo 1mo longiore quam 2dus.

G. 3. Thyropus, *Dana.*†—Pedes 5ti 6tique articulo 1mo late lamellati, articulis reliquis paulo abbreviatis. Antennæ 2dæ 4–5-plicatæ, sub thoracis latere celatæ, articulo 1mo multo breviore quam 2dus.

Subfam. 2. PRONOINÆ.—Abdomen in ventrem se non flectens. Caput non oblongum, antennis frontalibus.

G. 1. Pronoe, *Guèrin.*—Pedes 2di non prehensiles. Pedum 6 posticorum articuli 1mi lati, reliquâ parte paris 7mi fere obsoletâ.

G. 2. Lycæa, *Dana.*—Pedes 1mi 2dique subchelati. Articuli pedum 6 posticorum 1mi angusti, subæqui, reliquâ parte paris 7mi paulo abbreviatâ.

Subfam. 3. OXYCEPHALININÆ.—Abdomen in ventrem se non flectens. Caput oblongum, antennis 1mis superficiem capitis inferiorem insitis.

G. 1. Oxycephalus, *Edw.*—Caput breviter acuminatum. Styli caudales longitudine mediocres.

G. 2. Rhabdosoma, *White.*‡—Caput rostro longo styliformi armatum. Styli caudales valde elongati.

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* *Hypérines anormales* of Edwards, Crust. iii, 94. *Typhidæ*, Cat. Brit. Crust. Brit. Mus., 57.

† Species *Typhis ferox* (Edw.) is here included.

‡ Crust. Voy. Samarang, p. 63, pl. 13, f. 7.

Corrections.—Page 305, last line, for 92, read 192.—Page 306, 5 lines from bottom, for iii, read viii.